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PROCEEDINGS OF THE FIRST NMC/NESDIS/DOD CONFERENCE ON DMSP RETRIEVAL PRODUCTS, 14-15 APRIL 1992

Ronald G. Isaacs
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George Ohring
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3 August 1992

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PHILLIPS LABORATORY
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HANSCOM AIR FORCE BASE, MASSACHUSETTS 01731-5000

This technical report has been reviewed and is approved for publication.

Robert A. McClatchey

ROBERT A. McCLATCHEY, Director
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13. ABSTRACT *(Maximum 200 words)*

The Proceedings of the First Conference on DMSP Retrieval Products is a collection of state-of-the-art papers on products derived from the Defense Meteorological Satellite Program (DMSP) sensors, particularly the SSM/T and SSM/I products.

14. SUBJECT TERMS
Vertical moisture retrieval, temperature sensing, microwave humidity profile, Satellite Retrieval

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Introduction

The First Conference on Defense Meteorological Satellite Program (DMSP) Retrieval Products was planned by scientists at the National Oceanic and Atmospheric Administration (NOAA)'s National Meteorological Center (NMC), NOAA's National Environmental Satellite, Data, and Information Service (NESDIS), and the Department of Defense (DoD). The conference was held 14-15 April 1992 at the NOAA Science Center in Washington, DC. The objective of the conference was to bring together individuals from both the defense and civilian communities with a common goal of understanding the use of DMSP retrieval products. The format consisted of four sessions of contributed papers and a discussion session resulting in a series of recommendations. The conference Steering Committee consisted of E. Kalnay (NOAA/NMC), P. K. Rao (NOAA/NESDIS), and R. McClatchey of the Air Force Phillips Laboratory Geophysics Directorate (PL/GP). The meeting was organized by Atmospheric and Environmental Research, Inc. (AER).

The conference was attended by over 90 scientists interested in the generation and application of DMSP retrieval products. Among those represented were the government and academic research community, the major operational numerical weather prediction centers, and industry. The research community was represented by the Air Force Phillips Laboratory (PL), the Naval Research Laboratory (NRL), NOAA/NESDIS and the National Aeronautics and Space Administration (NASA). Operational centers included the NMC, the Navy's Fleet Numerical Oceanography Center (FNOC), Air Force Global Weather Central (AFGWC), the European Centre for Medium Range Weather Forecasts (ECMWF), and Canada's Atmospheric Environment Service (AES). DoD was also represented by Headquarters, Air Force Space Systems Division and the Air Weather Service. Industry representatives included those from GE Astro-Space, Lockheed, Hughes, and ITT.

This proceedings volume summarizes the technical presentations at the conference. The main part of the report consists of the abstracts and copies of the viewgraphs or slides and other material as provided by the authors for the presentations. Preceding the viewgraphs for each session is a commentary prepared by the co-chairpersons on each presentation within that session. The Appendix includes the original call for papers and invitation to the meeting, a copy of the Agenda for the meeting, a list of the attendees, and an author index.

We acknowledge the important contributions of the session chairmen E. Kalnay (NOAA/NMC), G. Ohring (NOAA/NESDIS), and R. McClatchey (PL/GP). Special thanks are also extended to E. Stenhouse of AER and Pam Taylor of NESDIS.

Received for publication 21 July 1992

Session 1: Overview of Current and Future DMSP Sensors and Products (Isaacs, chair)

The first session provided background information on current operational DMSP sensors and near term and far term plans. James Hollinger of the Naval Research Laboratory provided a status report on the performance, calibration, geolocation, and algorithm validation of the on orbit Special Sensor Microwave Imagers (SSM/I). Of particular note was data on the intercalibration of the three SSM/I's aboard F-08, F-10, and F-11. F-08 and F-10 compare well, while this is not so true for F-10 and F-11. Implications were described for the application of the calibration/validation retrieval algorithms.

Mike Griffin of the Phillips Laboratory presented an overview of the calibration/validation program for the recently launched DMSP microwave humidity profiler (SSM/T-2). The SSM/T-2 is a cross-track scanning microwave radiometer operating in the frequency range from 90 to 183 GHz. The mission of the SSM/T-2 is to provide high quality vertical moisture profiles that can be made available to a variety of models running operationally at the Air Force Global Weather Central (AFGWC). The SSM/T-2 sounder was launched late in 1991. Calibrations efforts will be performed by the Phillips Laboratory and validation efforts by the Aerospace Corporation. Calibration efforts for the SSM/T-2 microwave moisture sensor will be based on aircraft underflights and the use of radiative transfer models. Imagery from the DMSP Operational Linescan System (OLS) will be used to help identify heavy cloud areas which may impact on water vapor sounding accuracies.

Bruce Thomas of the Aerospace Corporation presented a companion paper on the SSM/T-2 moisture sounding algorithm validation effort. The algorithm currently used at AFGWC to extract the moisture profiles from the radiances is multiple linear regression. Historically, regression coefficients have been organized using simple static discriminates (i.e. latitude and longitude as for the SSM/T-1). The SSM/T-2 breaks with this transition and attempts to build a "dynamically based" set of piece wise linear regression coefficients stratified by air mass. A brief discussion on the choice of discriminants for air mass typing was presented. Early analysis of SSM/T-2 data shows the instrument to be quite stable with sensor noise below that of the original specifications. Aerospace is in the process of validating the SSM/T-2 derived moisture profiles (against synoptic time and special radiosondes).

Capt. Mark Borden of Headquarters, Air Force Space Systems Division described plans for the next generation of DMSP weather satellite: the DMSP Block 6. The Block 6 program features an aggressive and innovative data driven strategy for the acquisition of the next generation DoD weather satellite. As a baseline it maintains the operational utility of the DoD weather satellite system while seeking to optimize operational efficiency within a specified life cycle cost cap. It features the development of a complete meteorological satellite system, embracing both space based and ground based assets. Particular attention is focused on the insertion of maturing technologies into the developing Block 6 effort. The system design concept responds to the data needs of the operational DoD user. System efficiencies are engendered through the use of data fusion, improved mass memory, sensors, power concepts and the application of Knowledge Based Systems (KBS) to optimize user efficiency.

SESSION 1: OVERVIEW OF CURRENT AND FUTURE DMSP SENSORS AND PRODUCTS

SSM/I: STATUS REPORT

James P. Hollinger

Radio, Infrared and Optical Sensing Branch
Center for Advanced Space Systems
Naval Research Laboratory
Washington, DC 20375

There are currently two SSM/I's in orbit, the Defense Meteorological Satellite Project Block 5D2 F-08 and F-10 satellites. A third is scheduled for launch in November 1991. An additional four SSM/I's along with five SSM/IS's, a follow on version of the SSM/I which incorporates atmospheric temperature and humidity sounding channels, will provide data into the twenty first century.

A brief description of the SSM/I will be presented followed by a status report on the performance, calibration, geolocation and algorithm validation of the SSM/I's in orbit.

SSM/I CALIBRATION AND VALIDATION OF SN004 ON DMSP F-11

- SENSOR HEALTH
  - SCAN PERIOD STABILITY
  - TEMPERATURE STABILITY
  - SYSTEM NOISE
  - GAIN STABILITY
  - REFERENCE LOAD STABILITY

- REGION COMPARISONS
  - AMAZON JUNGLE
  - ARABIAN DESERT
  - GREENLAND
  - CLEAR CALM OCEAN
  - SIMULTANEOUS DATA

- GEOLOCATION

F-11

- NEAR CIRCULAR ORBIT

- STABLE - NO GAIN STEPPING

- PERIOD
  - SHORT TERM 1.899 +/- 0.002 sec
  - LONG TERM 1.89900 sec

- HOT/COLD LOAD SAMPLES UNIFORM

- HOT LOAD TEMPERATURE UNIFORM +/- 0.1 K

- SYSTEM NOISE EXCELLENT

- GEOLOCATION
  - WITHIN SPEC (±7 Km)
  - BEAMS COLLOCATED

- CALIBRATION
  - 22V and 85V & H APPEAR ~ 1 TO 2 DEG HIGH
  - OTHER CHANNELS < 0.5 DEG

	F-8 REV 18532	F-10 REV 719	F-11 REV 1276
ASC EQUATOR X-ING TIME	06:35	19:42	17:04
PERIOD	101.8 MIN	100.7 MIN	101.9 MIN
ALTITUDE MAX	882 Km	853 Km	878 Km
ALTITUDE MIN	838 Km	740 Km	841 Km
ECCENTRICITY	0.00145	0.00814	0.00129
SEMI MAJOR - SEMI MINOR	8 M	238 M	6 M
FOCAL DISTANCE	21 Km	117 Km	19 Km
SWATH MAX	1480 Km	1427 Km	1483 Km
SWATH MIN	1400 Km	1226 Km	1414 Km
INCIDENCE ANGLE MAX	53.60 DEG	53.29 DEG	53.56 DEG
INCIDENCE ANGLE MIN	53.13 DEG	52.10 DEG	53.16 DEG
MAX INCIDENCE ANGLE CHANGE FOR ALL ORBITS	0.9 DEG	1.4 DEG	0.5 DEG

RADIOMETER SENSITIVITIES
HOT LOAD TARGET

	19V	19H	22V	37V	37H	85V	85H
SPEC	0.8	0.8	0.8	0.6	0.6	1.1	1.1
F-8 (Aug 1987)	0.37	0.37	0.58	0.30	0.33	0.69	0.59
F-10 (REV 6632)	0.50	0.48	0.54	0.37	0.37	0.53	0.57
F-11 (REV 1764)	0.46	0.39	0.55	0.34	0.35	0.58	0.44

AMAZON

F-11 AND F-10 NEAR COINCIDENT
DATA FOR 18 PASSES
AVERAGE TIME DIFFERENCE OF 187 MINUTES

CHANNEL	F-11 MEAN	F-10 MEAN	MEAN DELTA (F11-F10)	RMS
19V	285.65	286.06	-0.65	1.58
19H	284.10	284.26	-0.43	1.69
22V	286.03	284.36	1.48	1.29
37V	281.17	282.29	-1.31	1.60
37H	280.14	280.94	-1.03	1.69
85V	283.04	283.56	-0.58	2.16
85H	282.96	282.99	-0.09	2.40

ARABIAN DESERT

F-11 AND F-10 NEAR COINCIDENT
DATA FOR 18 PASSES
AVERAGE TIME DIFFERENCE OF 183 MINUTES

CHANNEL	F-11 MEAN	F-10 MEAN	MEAN DELTA (F11-F10)	RMS
19V	287.53	286.24	1.41	1.76
19H	246.79	245.52	1.26	1.95
22V	286.61	283.44	3.30	1.76
37V	282.47	281.95	0.71	2.40
37H	249.60	248.60	1.14	2.32
85V	281.70	279.80	2.05	3.26
85H	266.63	264.18	2.61	3.09

GREENLAND

F-11 AND F-10 NEAR COINCIDENT DATA FOR 21 PASSES AVERAGE TIME DIFFERENCE OF 132 MINUTES

CHANNEL	F-11 MEAN	F-10 MEAN	MEAN DELTA (F11-F10)	RMS
19V	192.28	192.71	-0.57	0.99
19H	141.54	141.10	-0.38	0.94
22V	186.94	185.95	0.87	0.85
37V	175.76	176.14	-0.48	0.53
37H	145.00	145.08	-0.09	0.63
85V	191.03	190.10	0.82	0.78
85H	169.14	167.67	1.44	1.26

CLEAR CALM OCEAN

	F-11	MODEL	DELTA (SSM/I - MODEL)		
			F-11	F-10	F-08
19V	179.2 ± 0.7	177.7	1.5	1.0	1.1
19H	100.6 ± 1.0	99.7	0.9	-0.3	0.9
22V	189.3 ± 1.4	187.1	2.2	1.6	0.5
37V	200.9 ± 0.5	205.2	-4.3	-2.3	-2.8
37H	129.2 ± 0.9	129.3	-0.1	-1.4	0.3
85V	236.4 ± 1.1	239.0	-2.6	-1.9	-4.3
85H	172.5 ± 2.0	173.7	-1.2	0.7	-1.1

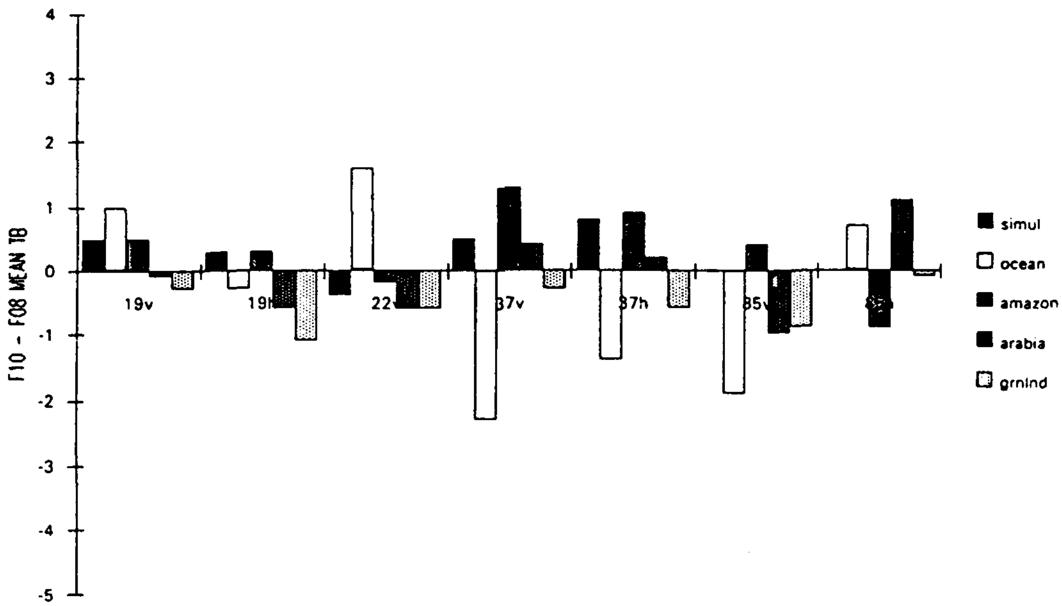
SIMULTANEOUS DATA MEAN DIFFERENCES

CHANNEL	F10 - F08		F11 - F10	
	MEAN	RMS	MEAN	RMS
19V	0.5	1.2	-0.2	0.1
19H	0.3	0.6	0.3	0.5
22V	-0.4	1.1	1.5	0.3
37V	0.5	1.3	-0.5	0.3
37H	0.8	0.7	0.0	0.4
85V	___	___	0.8	0.2
85H	___	___	1.3	0.2

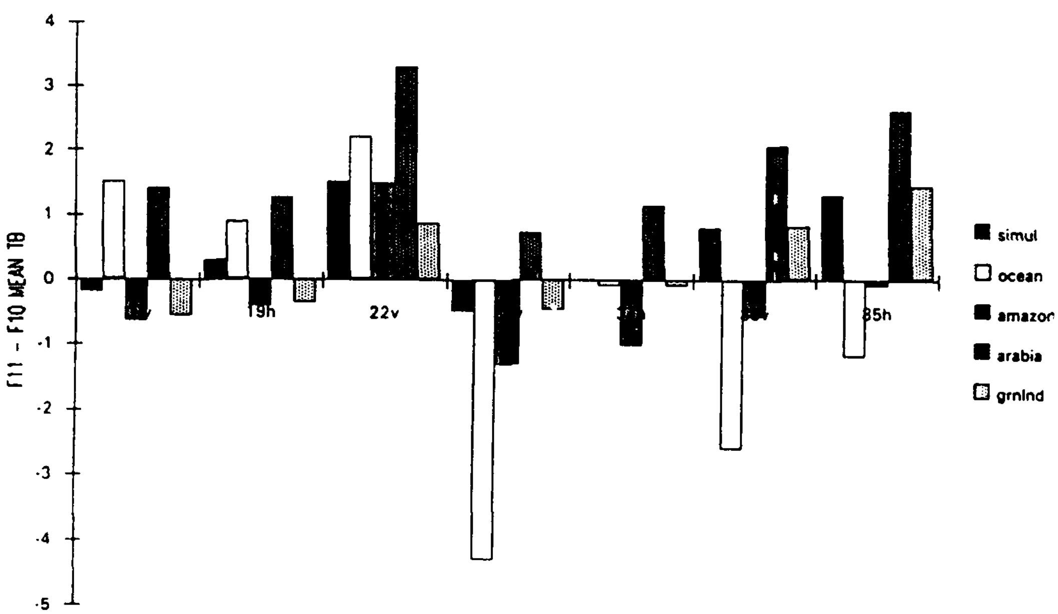
SUMMARY OF MEAN DIFFERENCES FOR
ARABIAN DESERT, AMAZON JUNGLE, GREENLAND,
CLEAR CALM OCEAN, AND SIMULTANEOUS DATA

CHANNEL	F10 - F08		F11 - F10	
	MEAN	RMS	MEAN	RMS
19V	0.0	0.5	0.0	1.6
19H	-0.5	0.7	0.4	1.6
22V	-0.3	0.4	1.6	1.8
37V	0.4	0.6	-0.5	1.7
37H	0.1	0.9	0.1	1.7
85V	0.3	1.5	0.6	2.3
85H	0.4	1.2	1.0	2.6

ABSOLUTE CALIBRATION ON F10 WITH F08



ABSOLUTE CALIBRATION OF F11 WITH F10



ALGORITHM RETREIVAL ERRORS FOR EQUAL CALIBRATION ERROR FOR EACH CHANNEL

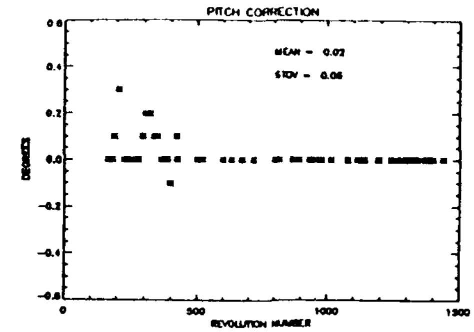
ALGORITHM	CALIBRATION ERROR	RETREIVAL ERROR
WIND SPEED	0.5	1.13 m/s
WATER VAPOR	0.5	0.38 kg/m^2
CLOUD WATER	0.5	0.01 kg/m^2
RAIN (OCEAN)	0.5	0.07 mm/hr
ICE (WINTER)	0.5	0.99 %
ICE (SUMMER)	0.5	1.50 %
ICE (37 GHz)	0.5	0.56 %
RAIN (LAND)	0.5	0.06 mm/hr

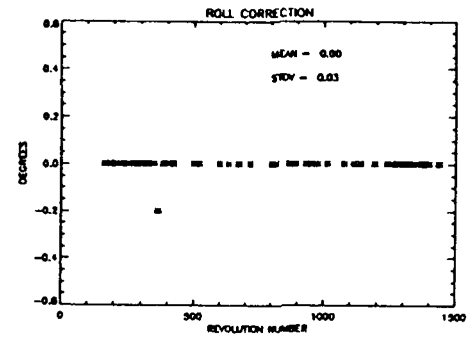
MAXIMUM ALLOWABLE ERRORS

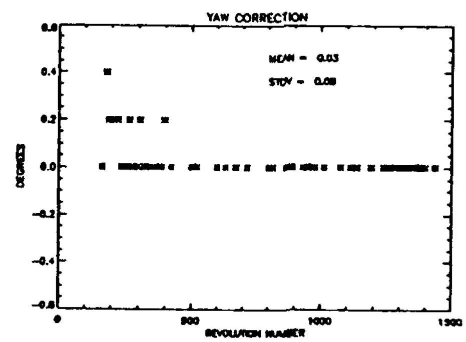
ALGORITHM	CALIBRATION ERROR	RETREIVAL SPECIFICATION
WIND SPEED	0.9	2.0 m/s
WATER VAPOR	2.6	2.0 kg/m^2
CLOUD WATER	4.7	0.1 kg/m^2
RAIN (OCEAN)	38.1	5.0 mm/hr
ICE (WINTER)	6.0	12.0 %
ICE (SUMMER)	4.0	12.0 %
ICE (37 GHz)	10.7	12.0 %
RAIN (LAND)	38.5	5.0 mm/hr

GEOLOCATION

- 50 Cases studied
  - 25 Ascending
  - 25 Descending
- 19 Regions
- Revolutions 164 - 1437 (12/10/91 - 3/9/92)
- Within Specification ($\pm$7 Km)


PITCH CORRECTION
DEGREES
REVOLUTION NUMBER


ROLL CORRECTION
DEGREES
REVOLUTION NUMBER


YAW CORRECTION
DEGREES
REVOLUTION NUMBER

CALIBRATION/VALIDATION OF THE DMSP MICROWAVE WATER VAPOR SOUNDER (SSM/T-2)

V. Falcone, J. Morrissey, M. Griffin

Phillips Laboratory
Geophysics Directorate (GPAS)
Hanscom AFB, MA 01731

D.J. Boucher and B.H. Thomas

The Aerospace Corporation
Defense Meteorological Satellite Program
PO Box 92957
Los Angeles, CA 90009

R.G. Isaacs and J. Pickle

Atmospheric and Environmental Research, Inc. (AER)
840 Memorial Drive, Cambridge, MA 02139

The SSM/T-2 sounder was launched late in 1991 and has the potential to provide global water vapor profiles for a variety of meteorological applications. We describe early results to calibrate the SSM/T-2 microwave moisture sensor based on aircraft underflights and the use of radiative transfer models. Imagery from the DMSP Operational Linescan System (OLS) is used to help identify heavy cloud areas which may impact on water vapor sounding accuracies. Also discussed are analyses of retrieved SSM/T-2 moisture soundings and comparisons to upper air soundings.

CONFERENCE ON DMSP RETRIEVAL PRODUCTS

Calibration/Validation of the DMSP Microwave Water Vapor Sounder (SSM/T-2)

Vincent J. Falcone, Jim Morrissey, Michael K. Griffin
PL/GP Atmospheric Sciences Division

John Pickle, Ron Isaacs
AER, Inc.

Bruce Thomas, Don Boucher
Aerospace Corporation

14 April 1992

Calibration and Validation of the SSM/T-2

Objectives

- Obtain Simultaneous, Independent Measurements of Microwave Radiance, Water Vapor Mass and Humidity to:

  1. Calibrate/Verify SSM/T-2 Brightness Temperatures Over Known Atmospheric and Surface Conditions
  2. Validate the AFGWC EDRs vs. Rawinsonde Data

Calibration and Validation Efforts

- PHILLIPS LABORATORY - **Calibration**
  Absolute Calibration - Underflights of Satellite
  Relative Calibration - Radiance Calculations

- AEROSPACE CORPORATION - **Validation**
  Compile and Analyze International Radiosonde Network Database Plus Supplemental Radiosonde Launches

14-15 April 1992 DMSP Retrieval Products Slide No. 3

Calibration Efforts

- Comparison of Satellite Measured Radiance With Aircraft Measured Radiance:

  NASA ER-2 Aircraft With a SSM/T-2 Lookalike Will Underfly F-11

- Comparison of Satellite Measured Radiance With Calculated Radiance:

  Forward Radiative Transfer Calculations Using Radiosonde Data

14-15 April 1992 DMSP Retrieval Products Slide No. 4

Calibration Participants

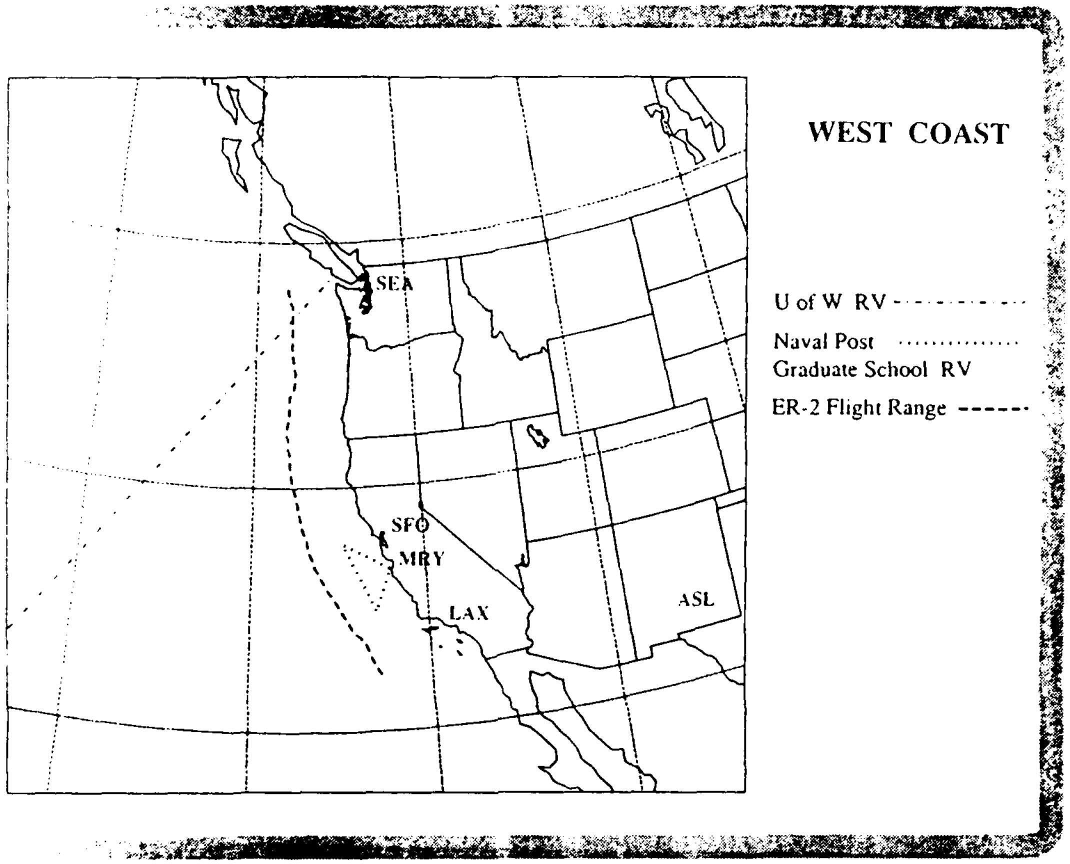
• PL/GPA	- Principal Investigators
• AER	- Analysis
• NASA	- ER-2 Flight Measurements West Coast U.S. May '92 East Coast U.S. July '92
• AEROSPACE	- SSM/T-2 Data Collection

14-15 April 1992 DMSP Retrieval Products Slide No. 5

Millimeter-Wave Imaging Radiometer (MIR)

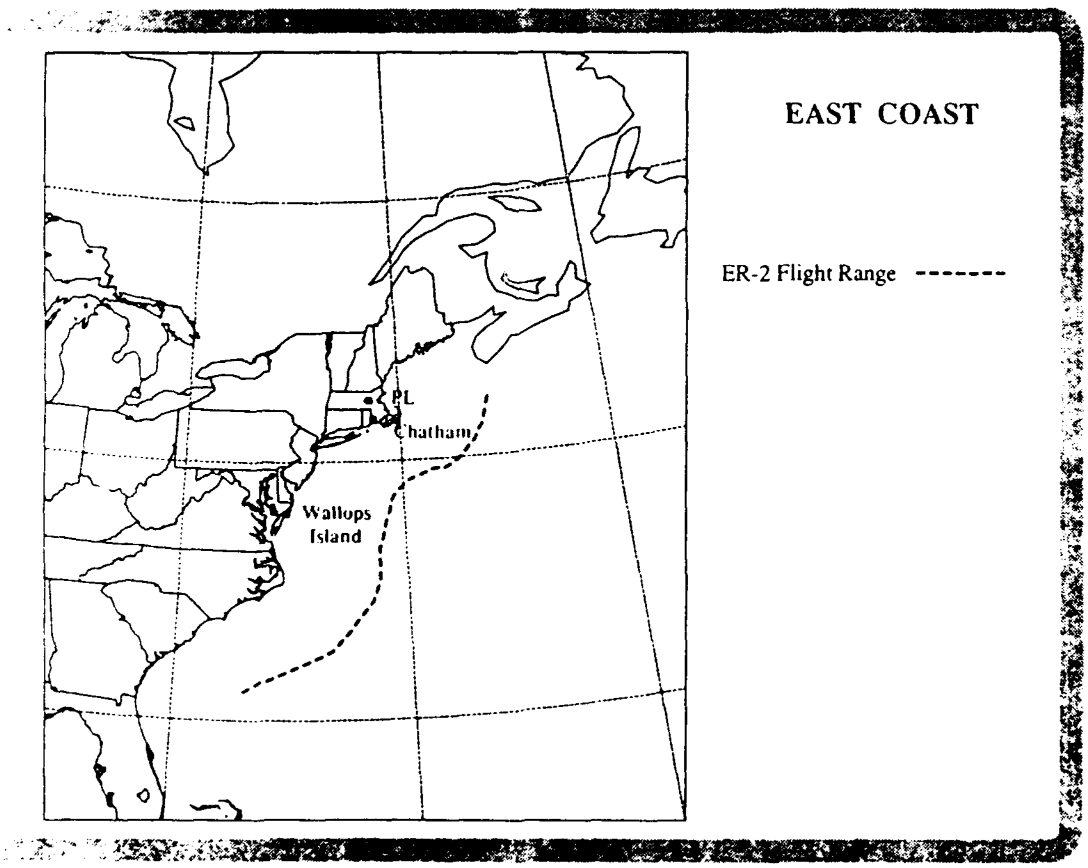
- Channels: 89, 150, 183.31$\pm$1, $\pm$3, $\pm$7, 220 and 325 GHz
- Scan: Cross-track (50 samples in 2.9 Seconds)
- Calibration: External to Antenna
- Main Beam: 3.5° FOV (1.2 km Footprint)
- Total Power Radiometer

14-15 April 1992 DMSP Retrieval Products Slide No. 6



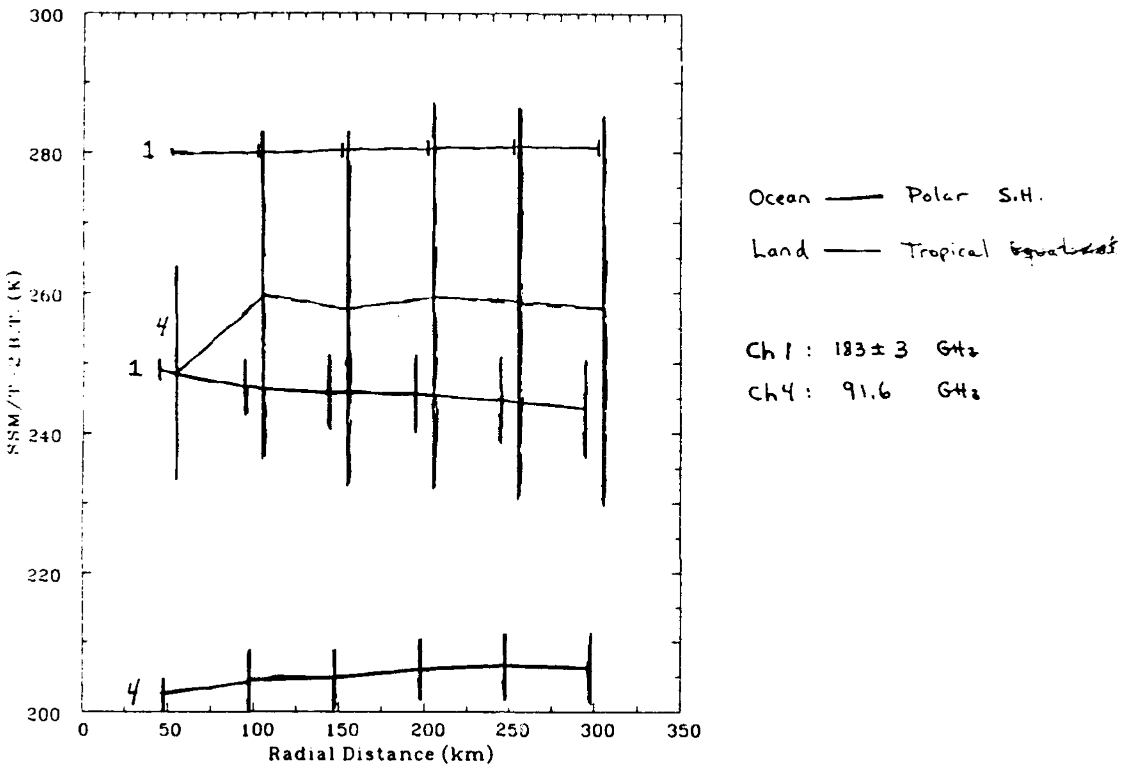
14-15 April 1992

DMSP Retrieval Products Slide



14-15 April 1992

DMSP Retrieval Products Slide


300
280
260
240
220
200
SSM/T-2 B.T. (K)
1
4
1
4
0
50
100
150
200
250
300
350
Radial Distance (km)
Ocean —— Polar S.H.
Land —— Tropical ~~Equatorial~~
Ch 1 : 183 ± 3 GHz
Ch 4 : 91.6 GHz

PERFORMANCE OF DMSP SPECIAL SENSOR MICROWAVE HUMIDITY PROFILER (SSM/T-2): PRELIMINARY RESULTS

Donald J. Boucher and Bruce H. Thomas

The Aerospace Corporation
Defense Meteorological Satellite Program
PO Box 92957
Los Angeles, CA 90009

The SSM/T-2 is a cross-track scanning microwave radiometer operating in the frequency range from 90 to 183 GHz. The mission of the SSM/T-2 is to provide high quality vertical moisture profiles that can be made available to a variety of models running operationally at the Air Force Global Weather Central (AFGWC). The algorithm currently used at AFGWC to extract the moisture profiles from the radiances is multiple linear regression. Historically, regression coefficients have been organized using simple static discriminates (i.e. latitude and longitude as for the SSM/T-1). The SSM/T-2 breaks with this transition and attempts to build a "dynamically based" set of piece wise linear regression coefficients stratified by air mass. A brief discussion on the choice of discriminates for air mass typing will be presented. In addition, Aerospace is in the process of validating the SSM/T-2 derived moisture profiles (against synoptic time and special radiosondes) and will present preliminary retrieval results.

Performance of the DMSP Special Sensor Microwave Humidity Profiler (SSM/T-2): Preliminary Results

by

Donald J. Boucher
Bruce H. Thomas

The Aerospace Corporation
Defense Meteorological Satellite Program

Vincent J. Falcone

Phillips Laboratories
Satellite Meteorology

Overview

Calibration/Validation data collection efforts

SSM/T-2 hardware performance on orbit

Aerojet Electro Systems (AES) moisture profile retrieval approach

Moisture retrieval analysis

Summary

SSM/T-2 Calibration/Validation Datasave

Data collection has been accomplished by Aerospace Corporation personnel assigned to HQ/AFGWC, Offutt AFB, Nebraska

Initial version of the SSM/T-2 ground processing software used to support Cal/Val

- Software errors have impacted segments of the SSM/T-2 data collected to date; data are recoverable

Initial dataset

- 30 Jan - 8 Mar 1992

Additional datasaves as required; field experiments, seasonal samples, etc.

Data types collected

- DMSP OLS & NOAA AVHRR visual and infrared imagery (smooth, 3nm); AFGWC'S Satellite Global DataBase (SGDB), polar stereographic
- F-11 DMSP special sensor; SSM/I, SSM/T-1, and SSM/T-2
  - Raw sensor data has been archived for recall as necessary

SSM/T-2 Calibration/Validation Datasave Cont

- Sensor Data Records (SDRs); earth located, antenna pattern corrected brightness temperatures
- Environmental Data Records (EDRs); temperature and moisture profiles, surface winds, rain rates, etc.

Conventional observations; WMO radiosondes worldwide, synoptic and asynoptic

AFGWC model data; every 3 or 6 hrs where available

- High Resolution Analysis System (HiRAS)
  - Analysis fields; temperatures, heights, U-V winds, and relative humidity spanning the surface to 10 mb
- Global Spectra Model (GSM)
  - 0 hr forecast fields (normal modes initialization); temperatures, heights, U-V winds, and relative humidity spanning 1000-10 mb
  - 6 hr forecast fields; temperatures, heights, U-V winds, and relative humidity spanning 1000-10 mb
- Real-Time NEPHanalysis (RTNEPH)

SSM/T-2 Hardware Performance on Orbit

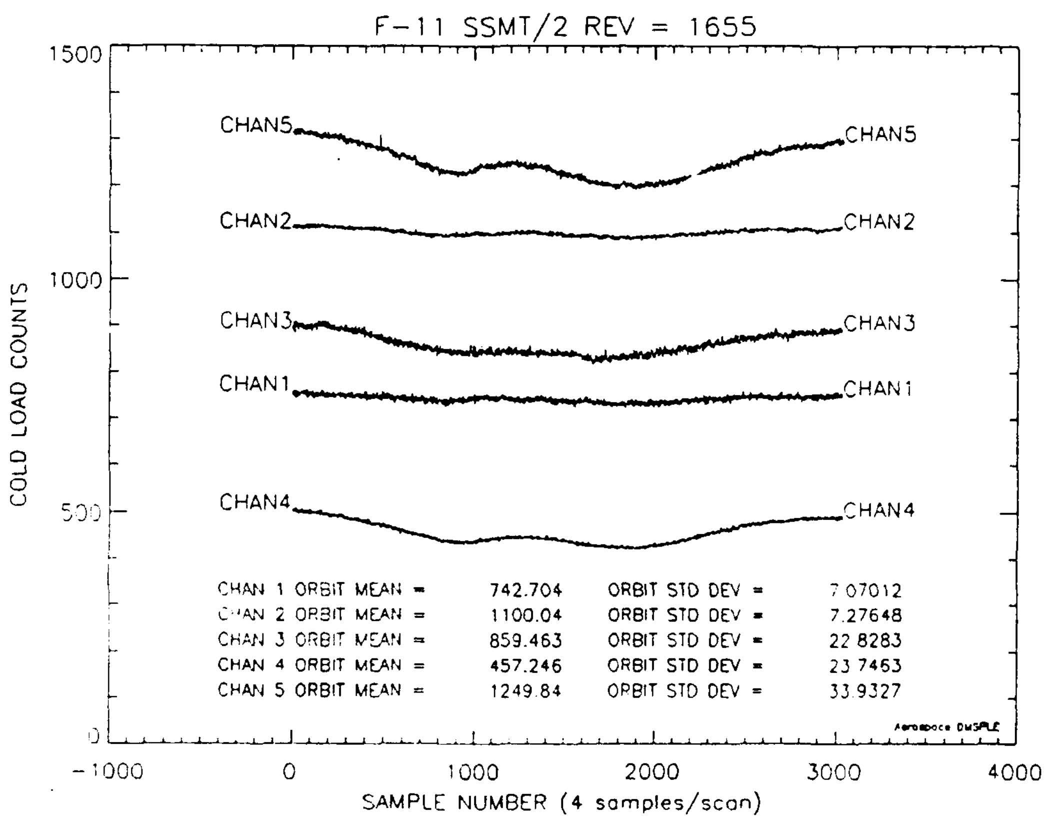
All channels meet or exceed the required specifications (.5 Kelvins NEDT)

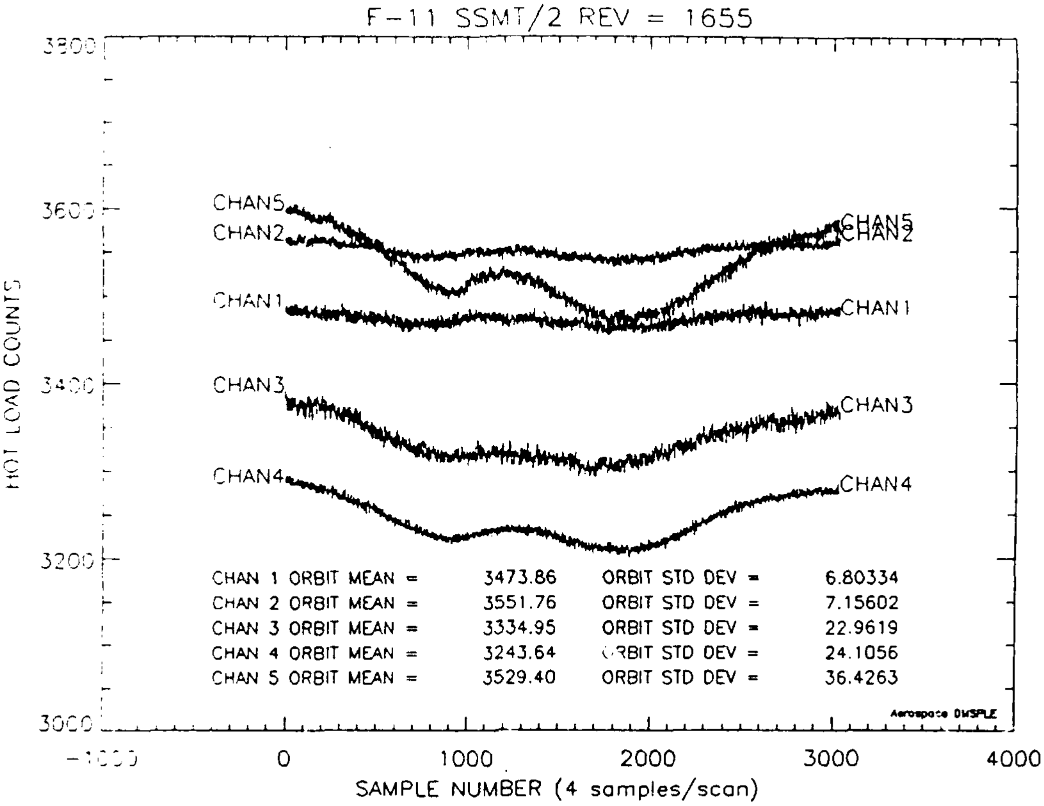
First 1600 satellite revolutions have demonstrated the sensor's stability

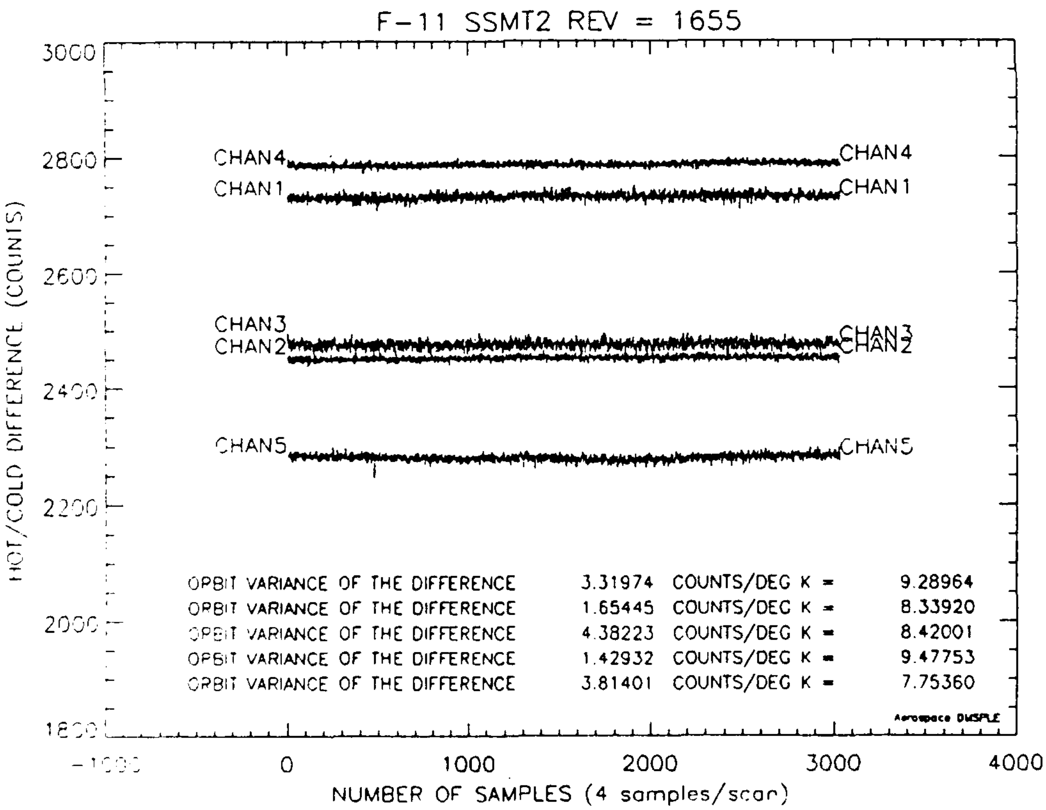
Revolution 1655 summary (units = Kelvins)

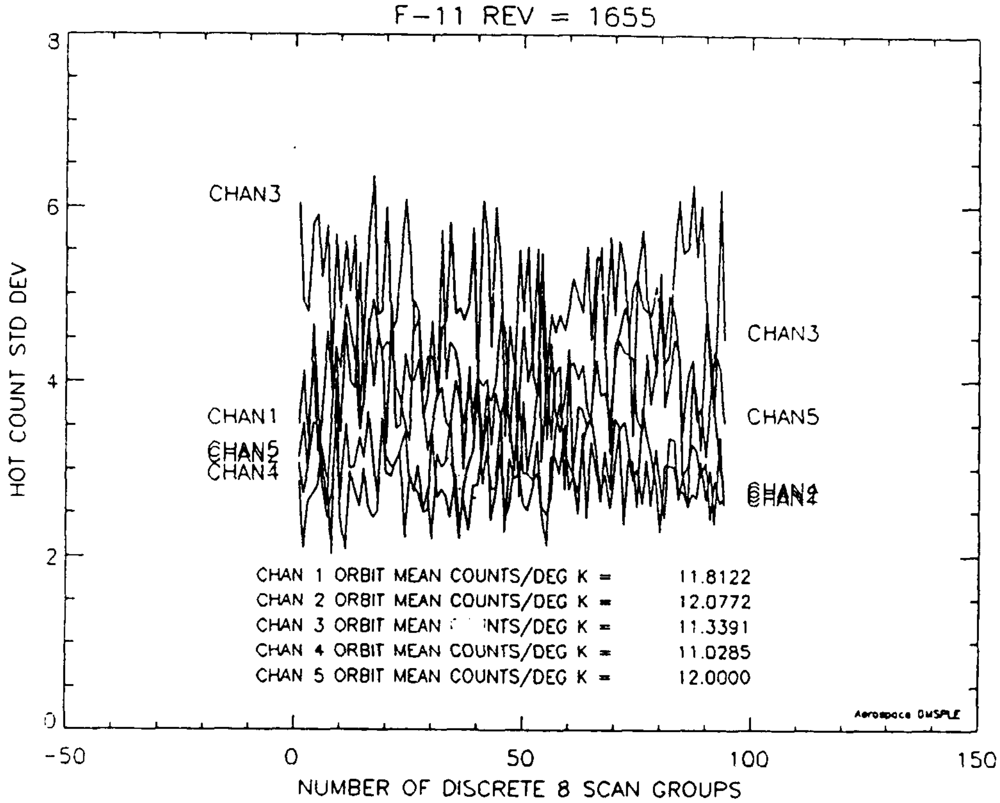
- Channel 1 (183 +/- 3 GHz) NEDT = .34
- Channel 2 (183 +/- 1 GHz) NEDT = .25
- Channel 3 (183 +/- 7 GHz) NEDT = .46
- Channel 4 (91.655 GHz) NEDT = .27
- Channel 5 (150.00 GHz) NEDT = .33

The absolute calibration of the sensor will be determined by the Phillips Laboratory component of the Cal/Val team by; utilizing radiative transfer modeling, aircraft flights with similar microwave instruments, etc. Details were presented in the previous briefing!




F-11 SSMT/2 REV = 1655
HOT LOAD COUNTS
SAMPLE NUMBER (4 samples/scan)
CHAN5
CHAN2
CHAN1
CHAN3
CHAN4
CHAN 1 ORBIT MEAN = 3473.86 ORBIT STD DEV = 6.80334
CHAN 2 ORBIT MEAN = 3551.76 ORBIT STD DEV = 7.15602
CHAN 3 ORBIT MEAN = 3334.95 ORBIT STD DEV = 22.9619
CHAN 4 ORBIT MEAN = 3243.64 ORBIT STD DEV = 24.1056
CHAN 5 ORBIT MEAN = 3529.40 ORBIT STD DEV = 36.4263
Aerospace DMSPLE


F-11 SSMT2 REV = 1655
HOT/COLD DIFFERENCE (COUNTS)
NUMBER OF SAMPLES (4 samples/scan)
CHAN4
CHAN1
CHAN3
CHAN2
CHAN5
ORBIT VARIANCE OF THE DIFFERENCE 3.31974 COUNTS/DEG K = 9.28964
ORBIT VARIANCE OF THE DIFFERENCE 1.65445 COUNTS/DEG K = 8.33920
ORBIT VARIANCE OF THE DIFFERENCE 4.38223 COUNTS/DEG K = 8.42001
ORBIT VARIANCE OF THE DIFFERENCE 1.42932 COUNTS/DEG K = 9.47753
ORBIT VARIANCE OF THE DIFFERENCE 3.81401 COUNTS/DEG K = 7.75360
Aerospace DMSPLE



Aerojet SSM/T-2 Retrieval Approach

Statistical Approach (multiple linear regression, D-matrix)

- Piece-wise linear approximation to non-linear water vapor distribution
- Air Mass Stratification (AMS)
  - Atmosphere Index is determined by:
    1) Surface type from eighth mesh database (ocean, land, ice, and coast)
    2) Estimating the total water vapor mass within the column
    3) Estimated high altitude water vapor mass; using terrain height adjusted brightness temperatures if necessary
    4) SSM/T-1 brightness temperatures of lower troposphere
       - Ocean: SSM/T-1 53.2 GHz brightness temperature threshold
       - Land: Terrain height adjusted SSM/T-1 50.5 and 53.2 GHz brightness temperatures and estimation of "high altitude" water vapor mass
       - Ice: SSM/T-1 53.2 GHz temperature threshold

Aerojet SSM/T-2 Retrieval Approach Cont

Coast: Terrain height adjusted SSM/T-1 53.2 GHz temperature threshold ** Note, SSM/T-2 91 and 150 GHz and SSM/T-1 50.5 GHz not used due to high variations of surface emissivity

Once the "air mass index" and terrain height is known, the proper D-matrix partition can be selected

The air mass stratification approach removes seasonal and latitude zone dependance when compared to the SSM/T-1 D-matrix partitions

**** Note: An air mass stratification scheme for the SSM/T-1 is planned for replacing the seasonal and latitude dependant D-matrix mechanism at AFGWC (1992-1993)**

Preliminary Moisture Retrieval Performance Analysis

Early focus has been placed on relative humidity retrieval accuracy

- Collocations of SSM/T-2 EDRs to RAOBs have provided approximately 470 matches/orbit within 1 hour and 100km (ideal orbit, 12z +/- 50 minutes)
  - 147 coastal matches from 22 RAOBs
  - 1 ice match from 1 RAOB
  - 22 ocean matches from 4 RAOBs
  - 301 land matches from 36 RAOBs
- Retrieval statistics not yet available

SSM/T-2 ground processing software errors have prevented analysis of non-ocean atmospheres, below 500 mb, because data are stored as missing. The problem is under investigation and will be corrected ASAP

Ocean retrievals appear to be very sensitive to SSM/T-1 lower atmospheric channel data (as expected), however, resultant EDR imagery shows the <u>non-physical</u> gradients/hatching based upon SSM/T-1 scan geometry and resolution

Summary

Data collection efforts have provided an initial dataset for the Cal/Val analysis with provisions for additional samples as necessary

Initial SSM/T-2 ground processing software contains errors which have impacted the data quality supplied to the Cal/Val team; corrections pending and data are recoverable

SSM/T-2 hardware preforming well on orbit; well within contract specifications

Absolute calibration, TBD by Phillips Labs, may impact validation work and the corresponding accuracy assessment

Aerojet's "piece wise multiple-linear regression" mechanism provides interesting approach to water vapor retrievals; remains under investigation for accuracy

DMSP BLOCK 6: A DATA DRIVEN APPROACH

M.W. Borden, F. Kelly and G. Mandt

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(SSD/MWB)
PO Box 92960
Los Angeles AFB, CA 90009-92960

D. L. Glackin and J. Bohlson

The Aerospace Corporation
Defense Meteorological Satellite Program
PO Box 92957
Los Angeles, CA 90009

The DMSP Block 6 program features an aggressive and innovative data driven strategy for the acquisition of the next generation DoD weather satellite. The Block 6 program maintains, as a baseline, the operational utility of the DoD weather satellite system while seeking to optimize operational efficiency within a specified life cycle cost cap. It features the development of a complete meteorological satellite system, embracing both space based and ground based assets. Particular attention is focused on the insertion of maturing technologies into the developing Block 6 effort. The system design concept responds to the data needs of the operational DoD User. System efficiencies are engendered through the use of data fusion, improved mass memory, sensors, power concepts and the application of Knowledge Based Systems (KBS) to optimize User efficiency.

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DMSP BLOCK 6:
A DATA DRIVEN APPROACH

PRESENTED BY:
CAPT MARK W. BORDEN

DEFENSE METEOROLOGICAL SATELLITE PROGRAM

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OVERVIEW

- DMSP MISSION
- DMSP BLOCK 6
- BLOCK 6 REQUIREMENTS
- BLOCK 6 CAPABILITIES
- BLOCK 6 STATUS

DEFENSE METEOROLOGICAL SATELLITE PROGRAM

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DMSP MISSION

- COLLECT
  - VISIBLE AND IR CLOUD DATA
  - OTHER METEOROLOGICAL, TERRESTRIAL, OCEANOGRAPHIC AND SOLAR-GEOPHYSICAL DATA
- DISSEMINATE
  - GLOBAL DATA TO STRATEGIC USERS
  - REAL-TIME DATA TO TACTICAL USERS

DEFENSE METEOROLOGICAL SATELLITE PROGRAM

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DMSP BLOCK 6

- EVOLUTIONARY DEVELOPMENT OF DMSP BLOCK 5D-3
  - CONTINUE TO PROVIDE 5D-3 CAPABILITY
  - ATMOSPHERE, OCEANS, LAND, SOLAR-GEOPHYSICAL
  - TRI-SERVICES
  - ADD LOW COST AND IMPACT, HIGH YIELD IMPROVEMENTS
  - WITHIN COST CAP FOR DEVELOPMENT + 10 YEARS OPERATION
  - ENHANCED CAPABILITIES VIA PRICED OPTIONS
  - FY 2005 INITIAL OPERATIONAL CAPABILITY
- CONCEPT STUDY COMPLETED (JAN 88 – APR 91) – 4 CONTRACTORS
- RISK REDUCTION PHASE IN PROGRESS – 2 CONTRACTORS
- SYSTEMS QUAL/INITIAL PRODUCTION FY 98

DEFENSE METEOROLOGICAL SATELLITE PROGRAM

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BLOCK 6 REQUIREMENTS

- BASELINE 5D–3 CAPABILITY
- IMPROVEMENTS FROM JCS ENVIRONMENTAL DATA LIST
  - VISIBILITY, SEA SURFACE TEMP, IMAGER RESOLUTION...
- INDIVIDUAL AGENCY INPUTS
  - AIR WEATHER SERVICE
  - SPACE COMMAND
  - NAVY
  - ARMY
  - DEPARTMENT OF COMMERCE (POSSIBLE REQUIREMENTS)

DEFENSE METEOROLOGICAL SATELLITE PROGRAM

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BASELINE SENSOR COMPLEMENT

- ELECTRO–OPTICAL IMAGING SUITE
  - $\geq$ 7 BANDS, 0.4 – 12.5 um
- MICROWAVE IMAGER SOUNDER SUITE
  - IMAGER $\geq$ 7 CHANNELS, 4 WAVELENGTHS, DUAL POLARIZATION, 19 – 91 GHz
  - TEMPERATURE SOUNDER TBD CHANNELS, 50 – 60 GHz
  - MOISTURE SOUNDER 4 CHANNELS, 150 – 183 GHz
  - SEPARATE OR COMBINED SCANS
- SOLAR GEOPHYSICAL SENSORS
  - TBD
- NAVY OPTION
  - ALTIMETER AND SCATTEROMETER POSSIBLE

DEFENSE METEOROLOGICAL SATELLITE PROGRAM

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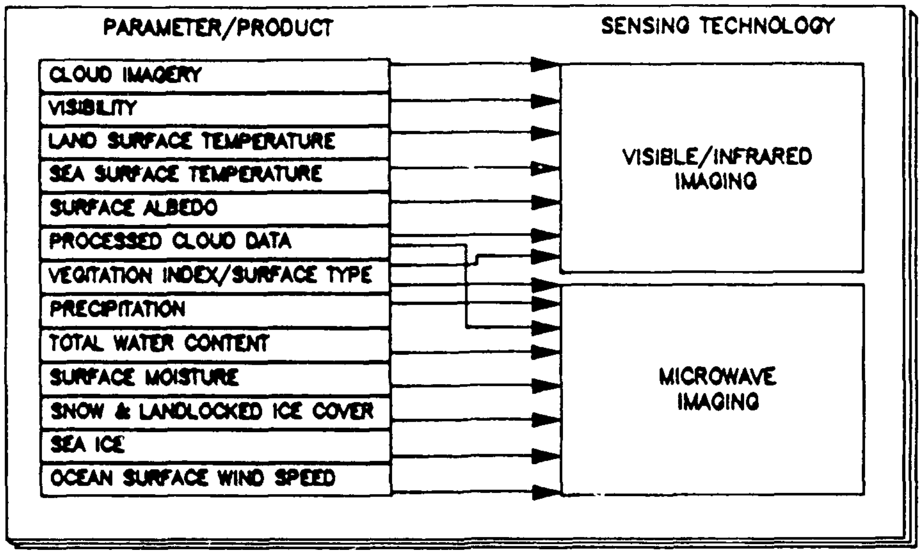
DATA PARAMETER CORRELATION



DEFENSE METEOROLOGICAL SATELLITE PROGRAM

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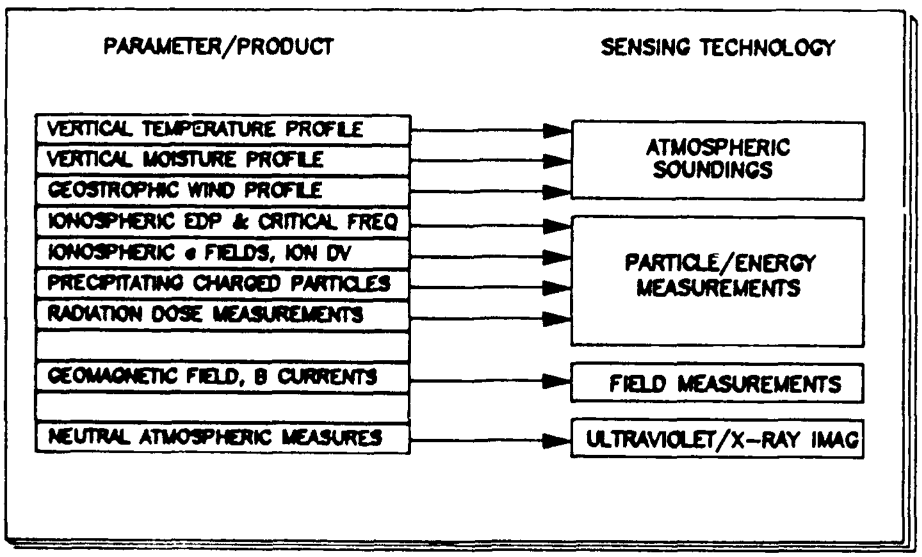
DATA PARAMETER CORRELATION



DEFENSE METEOROLOGICAL SATELLITE PROGRAM

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TECHNOLOGY DEVELOPMENT IMPACTS

- DATA FUSION
  - SYNERGISM OF MICROWAVE, IR AND VISIBLE DATA
  - ONGOING PROJECTS THROUGH AF SBIR
- MASS MEMORY
  - TAPE RECORDERS LIMITING TODAY – MORE SO IN BLOCK 6 TIMEFRAME
  - POTENTIAL MASS MEMORY UPGRADES
    - SOLID STATE MEMORY DEVICES
    - REWRITABLE OPTICAL DISK DEVICES
- SENSORS
  - ELLSE
  - LIDAR
  - HIGH ANGLE MICROWAVE
- POWER
  - PASP PLUS
  - NIH BATTERIES
- KNOWLEDGE BASED SYSTEMS
  - SAGE
  - ANOMALY AND STATION KEEPING ANALYSIS

DEFENSE METEOROLOGICAL SATELLITE PROGRAM

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KEY SENSOR RELATED DEMONSTRATIONS/EXPERIMENTS

- OMIS ENGINEERING DEVELOPMENT UNIT
  - BENCH TEST UNIT
  - INCORPORATE CHANNELS 1 – 6
- EXPERIMENTAL LOW LIGHT SENSOR (ELLSE)
  - OMIS CHANNEL 6 (NIGHT CLOUD & AURORAL IMAGERY)
  - IMPROVED RESOLUTION & LOW RADIANCE GOALS
  - OPTIONAL SPACE FLIGHT TEST
- HIGH EARTH INCIDENCE ANGLE MICROWAVE SENSING
  - NORTH SEA TOWER TESTS (NRL)
  - SURFACE EMISSIVITY STUDIES/MODELING (PL)
  - MAY GIVE CONTIGUOUS MISS DATA

DEFENSE METEOROLOGICAL SATELLITE PROGRAM

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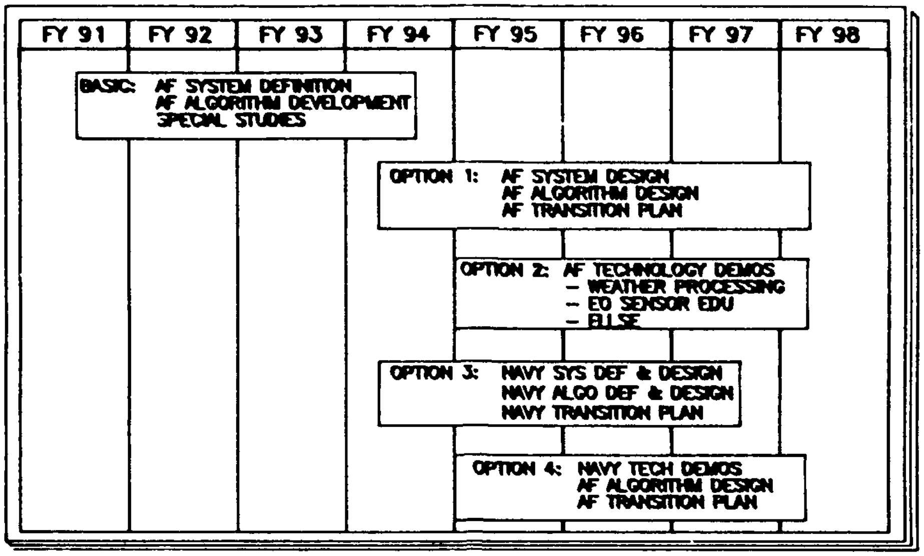
CONTRACT STRUCTURE



DEFENSE METEOROLOGICAL SATELLITE PROGRAM

Session 2: Operational and Quasi-operational Retrieval Approaches and Products (McClatchey, chair)

This session dealt with the interpretation and dissemination of current DMSP microwave products, the algorithms used to generate them and the system used to distribute the results. There also was considerable focus on research efforts being conducted to determine the accuracy of current operational algorithms and to evaluate new and different algorithms. There were two papers on the SSM/T-1, the DMSP temperature sounder, and ten on the SSM/I, the DMSP microwave imager. The paper presented by Capt. T. Neu of the Air Force Global Weather Central described the processing of data from these two systems as well as the new moisture sounder, SSM/T-2 and the future SSMIS which will integrate the DMSP sounder and imager into a single system.

The two papers on SSM/T-1 dealt with the shared processing network and products. Temperature products are being made available, but are being used by NMC as backup to TOVS. T. Reale of NOAA/NESDIS suggested that the DMSP accuracy appears to be worse than TOVS, although he indicated that the change from seasonal to weekly updating of the statistical data base used in the retrieval process has improved the results somewhat. In a comment made from the audience, H. Woolf of NOAA/NESDIS (Madison, Wisconsin) expressed the view that the DMSP results are not all that much different than TOVS. Perhaps we need to determine a more satisfactory basis of comparison for satellite retrieved products which is more consistent with the nature of the sensing technique.

The future availability of data from the Microwave Water Vapor Profiler (SSM/T-2) discussed by Capt. Neu was met with substantial interest. Of course, the determination of water vapor profiles will depend strongly on the temperature profiles determined from the SSM/T-1.

The remaining ten papers all related to SSM/I data processing, data distribution and alternative algorithm design and testing. M. Colton described how the Navy's Fleet Numerical Oceanographic Center (FNOC) applies the Hughs algorithm and distributes the results over the Shared Processing Network (SPN). J. Fiore of SM Systems and Research Corp. described a testbed that has been developed for the same data base. He emphasized the comparison of total precipitable water algorithms. J. Alishouse described alternative algorithms for Total Precipitable Water and the need for further validation and quality control. N. Grody and R. Ferraro are evaluating precipitation and surface products. W. Pichel is evaluating ice and wind products by comparison with ice analyses produced using visible and infrared imagery. And finally, the NASA-sponsored project, WETNET, was described by Jim Dodge of NASA Headquarters, standing in for M. Goodman of NASA Marshall Space Flight Center (MSFC). WETNET is a data distribution system offering people in the R&D community an opportunity to work with the necessary data sets for algorithm improvement with respect to SSM/I and eventually also SSM/T-1 and SSM/T-2.

SESSION 2: OPERATIONAL AND QUASI-OPERATIONAL RETRIEVAL APPROACHES AND PRODUCTS

NOAA/NESDIS OPERATIONAL PROCESSING OF SSM/T DATA

Ellen L. Burdsall

NOAA/NESDIS
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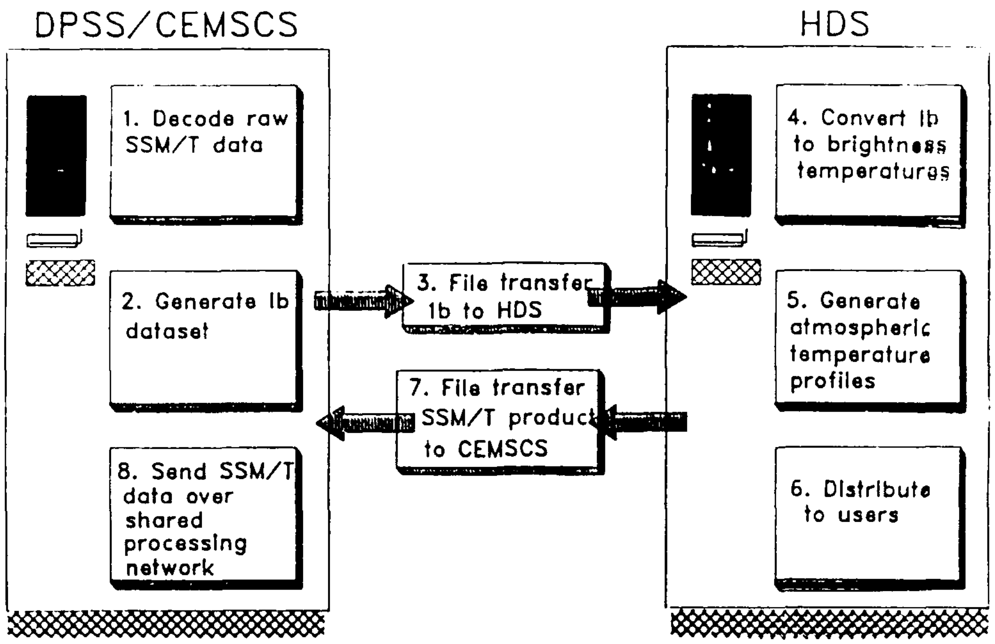
Since 1987, the National Oceanic and Atmospheric Administration (NOAA)/ National Environmental Satellite Data and Information Service (NESDIS) has been operationally producing vertical temperature profiles (soundings) from the Special Sensor Microwave/Temperature (SSM/T) instruments on the Defense Meteorological Satellite Program (DMSP) satellites. In the years since 1987, the NOAA/NESDIS SSM/T processing system has been enhanced and modified to improve the quality of soundings from the SSM/T instrument. A brief history of the SSM/T processing system will be presented. An overview of the current system will be discussed and data distribution and archive will be addressed in detail.

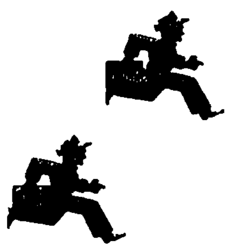
BRIEF HISTORY OF NESDIS SSM/T SOUNDING PROCESSING

1982	NESDIS RECEIVES SSM/T SOFTWARE DEVELOPED BY AEROJET
1985	AIR FORCE SENDS SSM/T DATA VIA LAND LINE (DATA ARCHIVED)
1986	SYNTHETIC REGRESSION RETRIEVAL METHOD REPLACED WITH SIMPLE MULTIPLE LINEAR REGRESSION
1986 – 1987	AIR FORCE SENDS SSM/T DATA VIA SHARED PROCESSING LINK

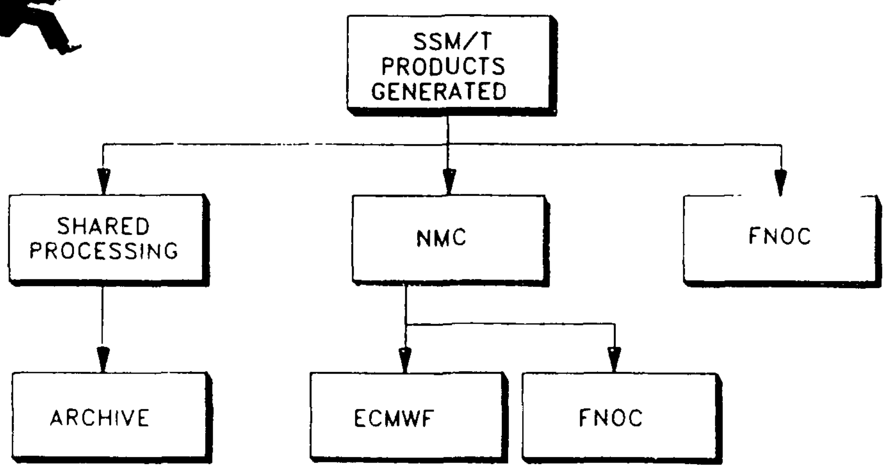
1987	JUNE - SSM/T OPERATIONAL PROCESSING AT NESDIS
1989	IMPLEMENT PRECIPITATION SCREENING ALGORITHM DEVELOPMENT BY DR. GRODY
1991	LIMB CORRECTION IMPLEMENTED

SSM/T PROCESSING AT NESDIS





DATA DISTRIBUTION



NMC

DATA –

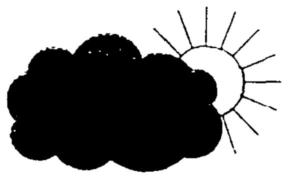
LAYER MEAN TEMPERATURE
BRIGHTNESS TEMPERATURE

DISTRIBUTION –

DISK FILE SHARED BY NMC AND NESDIS

USE –

BACKUP TO TOVS



ECMWF

DATA –

LAYER MEAN TEMPERATURE
BRIGHTNESS TEMPERATURE

DISTRIBUTION –

RECEIVED IN REALTIME FROM NMC

USE –

ANALYSIS AND BACKUP TO TOVS

NAVY – FNOC

DATA –

LAYER TEMPERTURE
BRIGHTNESS TEMPERATURE
GEOPOTENTIAL HEIGHTS

DISTRIBUTION –

TEMPERTAURE VALUES RECEIVED IN REALTIME FROM NMC

GEOPOTENTIAL HEIGHTS RECEIVED IN REALTIME FROM NESDIS

USE –

USED IN OPERATIONAL PROCESSING

ARCHIVE

DATA –

LAYER TEMPERTURE
LEVEL TEMPERATURE
BRIGHTNESS TEMPERATURE

PROCESS –

1B DATA SETS ARCHIVED DAILY
PRODUCT ARCHIVE PERFORMED WEEKLY

STORAGE –

SATELLITE DATA SERVICES DIVISION OF THE NATIONAL CLIMATIC DATA CENTER SERVICES ALL USER REQEUSTS FOR SSM/T DATA

NOAA/NESDIS SSM/T ALGORITHMS AND EVALUATION

Tony L. Reale and David Donahue

NOAA/NESDIS
Washington, DC 20233

Defense Meteorological Satellite Program (DMSP) sounding products are currently produced operationally by NESDIS and distributed to national and international users. Two sun synchronous DMSP polar orbiting satellites, each containing the seven channel Special Sensor Microwave/Temperature (SSM/T), sounder are being flown operationally. This provides an average of four independent measurements daily for most locations over the earth. The temperature soundings produced are from the surface to about 10 mb (30 km) with a nominal horizontal resolution of approximately 175 km. An overview of the current scientific algorithms to compute atmospheric sounding products from the SSM/T sounder measurements is presented. Results showing data at various stages of the radiance and sounding computation process are displayed. An evaluation of the sounding products accuracy based on vertical accuracy statistics relative to collocated radiosondes, and horizontal temperature fields relative to other satellite and conventional meteorological data is presented. Concluding remarks on future plans to upgrade the DMSP operational sounding products are provided.

NOAA NESDIS OPERATIONAL SSM/T SOUNDING ALGORITHM AND METEOROLOGICAL EVALUATION

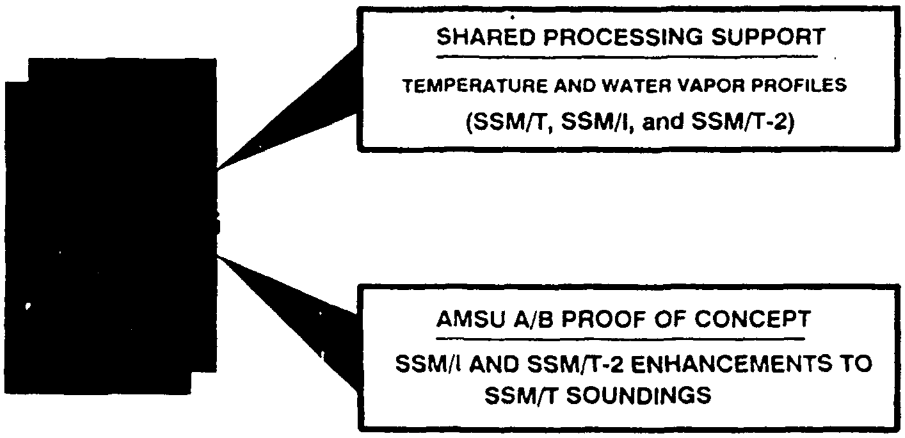
TONY REALE
DAVID DONAHUE
PAMELA TAYLOR

NOAA/NESDIS/ORA
SATELLITE APPLICATIONS LAB

OUTLINE

- OPERATIONAL SYSTEM
- SCIENCE ALGORITHMS AND APPLICATIONS
- SOUNDING ACCURACY
- METEOROLOGICAL CONSISTENCY

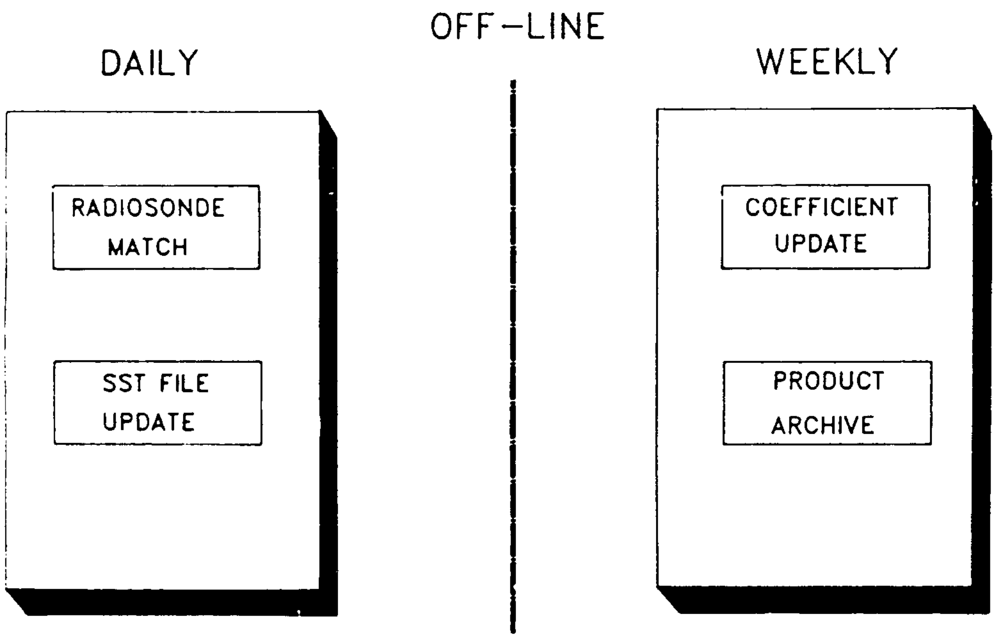
DMSP PROJECT



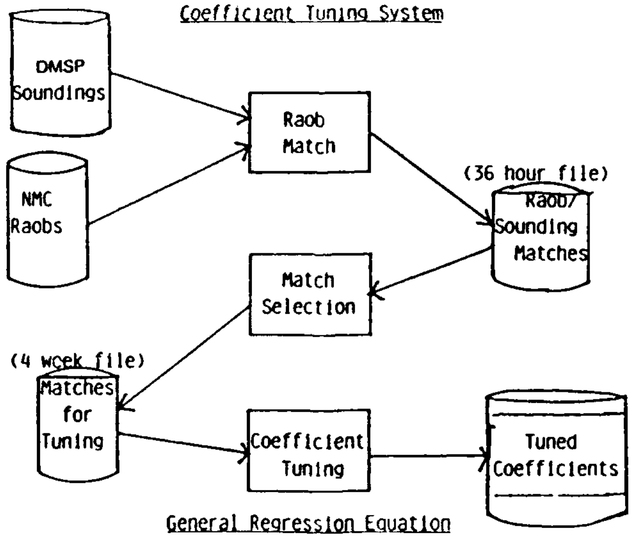
DMSP SOUNDINGS

- o PREPROCESS
- o TERRAIN/SURFACE CORRECTION
- o PRECIPITATION FILTER
- o STATISTICAL REGRESSION RETRIEVAL

SSM/T PROCESSING



Coefficient Tuning System

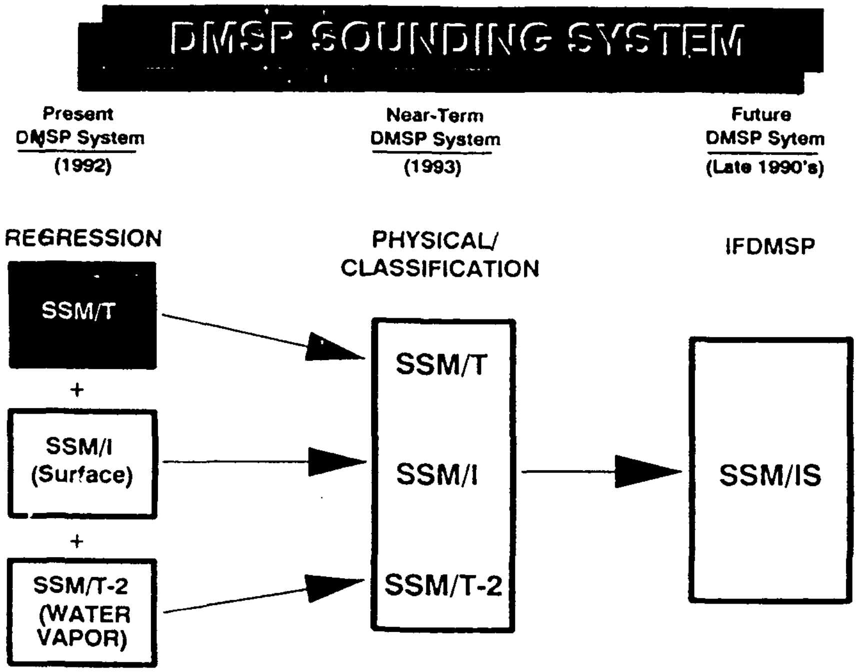


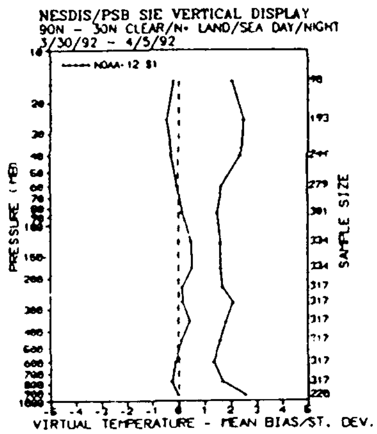
General Regression Equation

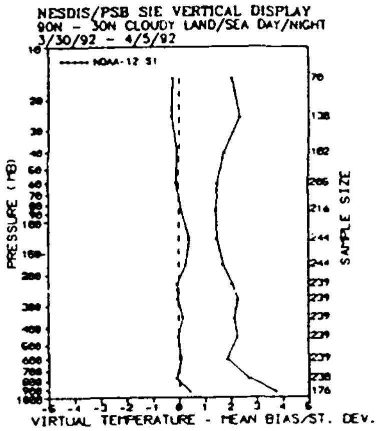
$$P_j = \bar{P}_j + \sum_{i=1}^{N} C_{i,j}(BT_i - \overline{BT}_i)$$

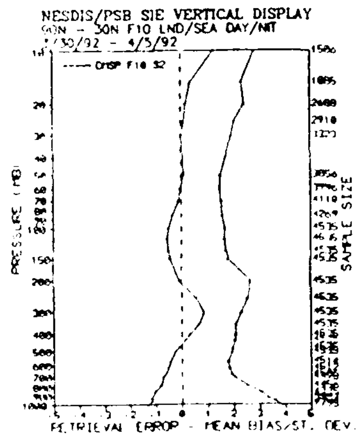
where:

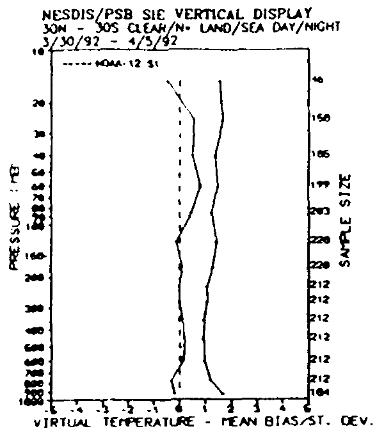
	i = Channel	N = Number of Channels
	j = Pressure Level	$C_{i,j}$ = Coefficients
	P_j = Atmospheric Parameter	BT_i = Brightness Temperature
	$\bar{P}_j$ = Mean Atmospheric Parameter	$\overline{BT}_i$ = Mean Brightness Temperature

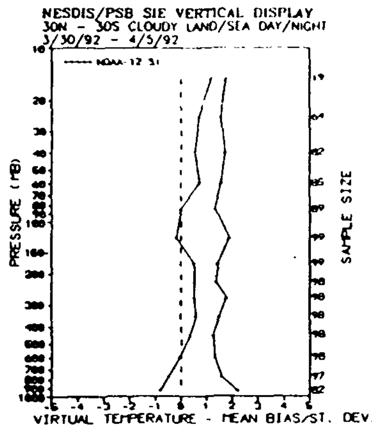

DMSP SOUNDING SYSTEM
Present
DMSP System
(1992)
Near-Term
DMSP System
(1993)
Future
DMSP Sytem
(Late 1990's)
REGRESSION
PHYSICAL/
CLASSIFICATION
IFDMSP
SSM/T
+
SSM/I
(Surface)
+
SSM/T-2
(WATER
VAPOR)
SSM/T
SSM/I
SSM/T-2
SSM/IS

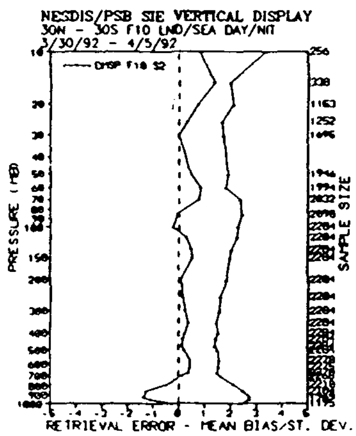

NESDIS/PSB SIE VERTICAL DISPLAY
90N - 30N CLEAR/N- LAND/SEA DAY/NIGHT
3/30/92 - 4/5/92
PRESSURE (MB)
SAMPLE SIZE
VIRTUAL TEMPERATURE - MEAN BIAS/ST. DEV.

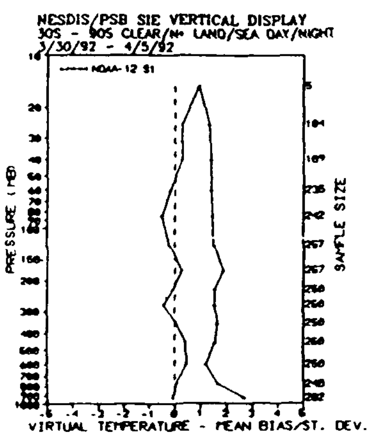

NESDIS/PSB SIE VERTICAL DISPLAY
90N - 30N CLOUDY LAND/SEA DAY/NIGHT
3/30/92 - 4/5/92
PRESSURE (MB)
SAMPLE SIZE
VIRTUAL TEMPERATURE - MEAN BIAS/ST. DEV.

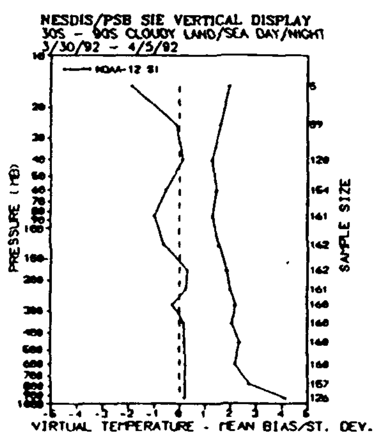

NESDIS/PSB SIE VERTICAL DISPLAY
SAMPLE SIZE

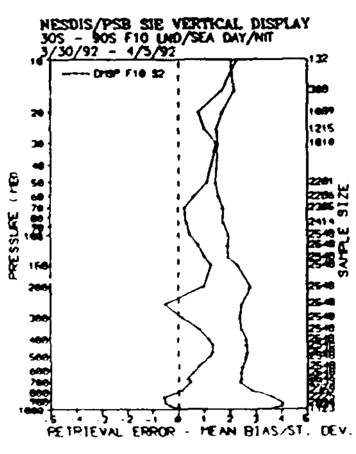

NESDIS/PSB SIE VERTICAL DISPLAY
30N - 30S CLEAR/N* LAND/SEA DAY/NIGHT
3/30/92 - 4/5/92
NOAA-12 S1
PRESSURE (MB)
SAMPLE SIZE
VIRTUAL TEMPERATURE - MEAN BIAS/ST. DEV.


NESDIS/PSB SIE VERTICAL DISPLAY
30N - 30S CLOUDY LAND/SEA DAY/NIGHT
3/30/92 - 4/5/92
NOAA-12 S1
PRESSURE (MB)
SAMPLE SIZE
VIRTUAL TEMPERATURE - MEAN BIAS/ST. DEV.


NESDIS/PSB SIE VERTICAL DISPLAY
30N - 30S F10 LND/SEA DAY/NIT
3/30/92 - 4/5/92
DMSP F10 S2
PRESSURE (MB)
SAMPLE SIZE
RETRIEVAL ERROR - MEAN BIAS/ST. DEV.


NESDIS/PSB SIE VERTICAL DISPLAY
30S - 90S CLEAR/N* LAND/SEA DAY/NIGHT
3/30/92 - 4/5/92
NOAA-12 S1
PRESSURE (MB)
SAMPLE SIZE
VIRTUAL TEMPERATURE - MEAN BIAS/ST. DEV.


NESDIS/PSB SIE VERTICAL DISPLAY
30S - 90S CLOUDY LAND/SEA DAY/NIGHT
3/30/92 - 4/5/92
NOAA-12 S1
PRESSURE (MB)
SAMPLE SIZE
VIRTUAL TEMPERATURE - MEAN BIAS/ST. DEV.


NESDIS/PSB SIE VERTICAL DISPLAY
30S - 90S F10 LND/SEA DAY/NIT
3/30/92 - 4/5/92
DMSP F10 S2
PRESSURE (MB)
SAMPLE SIZE
RETRIEVAL ERROR - MEAN BIAS/ST. DEV.

C O N C L U S I O N S

- OPERATIONAL SOUNDINGS USING A STATISTICAL APPROACH
- ACCURACY COMPATIBLE TO TOVS CLOUDY SOUNDINGS
- CONSISTENT GLOBAL METOROLOGICAL REPRESENTATION
- VITAL PROOF-OF-CONCEPT FOR AMSU

DEFENSE METEOROLOGICAL SATELLITE PROGRAM MICROWAVE RADIOMETER PROCESSING AT AIR FORCE GLOBAL WEATHER CENTRAL

T.J. Neu

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The Department of Defense operates polar orbiting meteorological satellites as part of the Defense Meteorological Satellite Program (DMSP). Along with the primary visual and infrared sensor (OLS), the DMSP satellites carry three passive microwave radiometer sensors. These special sensors consist of the Microwave Imager (SSM/I), Microwave Temperature Sounder (SSM/T), and Microwave Water Vapor Profiler (SSM/T-2). Air Force Global Weather Central (AFGWC) at Offutt AFB is the sole Department of Defense location where all of the ground processing for these special sensors is performed. A brief review of DMSP orbital characteristics, data stream transmission, and data ingest to AFGWC computer systems will be presented. The general description, function, and uses of each microwave radiometer will then be discussed. Emphasis will be placed on operational retrieval approaches and products generated at AFGWC. An overview of the Microwave Imager Sounder (SSM/IS) will present technical enhancements and future integration of the sensor at AFGWC.

DMSP MICROWAVE RADIOMETER PROCESSING AT AFGWC

presented by

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TOPICS OF DISSCUSSION

1) DMSP OVERVIEW
2) SSM/I
3) SSM/T-1
4) SSM/T-2
5) USERS OF DATA
6) SSM/IS

DMSP SATELLITE SENSOR CONFIGURATION

	BLOCK 5D-2							BLOCK 5D-3	
SENSOR / SATELLITE	S8	S9	S10	S11	S12	S13	S14	S15	S16 thru S20
SENSOR / FLIGHT ID	F9	F8	F10		F11				
OLS Operational Linescan System	F	F	N	X	N	X	X	X	X
SSM/I Microwave Imager		DL	N	X	N	X	X	X	
SSM/T1 Microwave Temperature Sounder	DL	L	N	X	N	X	X	X	
SSM/T2 Microwave Water Vapor Profiler					N	X	X	X	
SSM/IS Microwave Imager Sounder									X

F = FAILURE D = DEGRADED L = LIMITED N = NOMINAL X = PLANNED AFGWC

1) **Orbital Characteristics:**

Orbit is polar sunsynchronous

Altitude of 450 Nautical miles (833 KM)

Period of 101.4 Minutes

Inclination of 98.7 Degrees

Local Time of Ascending Nodal Crossing: (LTAN)
F-8 = 0611, F-9 = 0930, F-10 = 1934 to 2112 ** , F-11 = 1700

** F-10 has an elliptical orbit which causes the nodal crossing time to precess 50 seconds per week. Limited use after 2112 LTAN in March 1993.

2) **Data Stream Transmission:**

Satellite recorder to downlink site: Pogo, Boston, Fairchild, Hula

Downlink site to DOMSAT: Atlantic or Pacific

DOMSAT to 1000 SOG at Offutt AFB, NE

1000 SOG to AFGWC Site III

Site III to AFGWC mainframe system 5 (UNISYS 1100/90)

SPECIAL SENSOR MICROWAVE IMAGER (SSM/I)

1) **Passively collects microwave energy**

   a) **Seven channels:** 19V, 19H, 22V, 37V, 37H, 85V, and 85H GHz

   b) **Antenna and sensor rotate** at 31.6 RPM

   c) **Conical sca** view of earth at an angle of 53.1 degrees

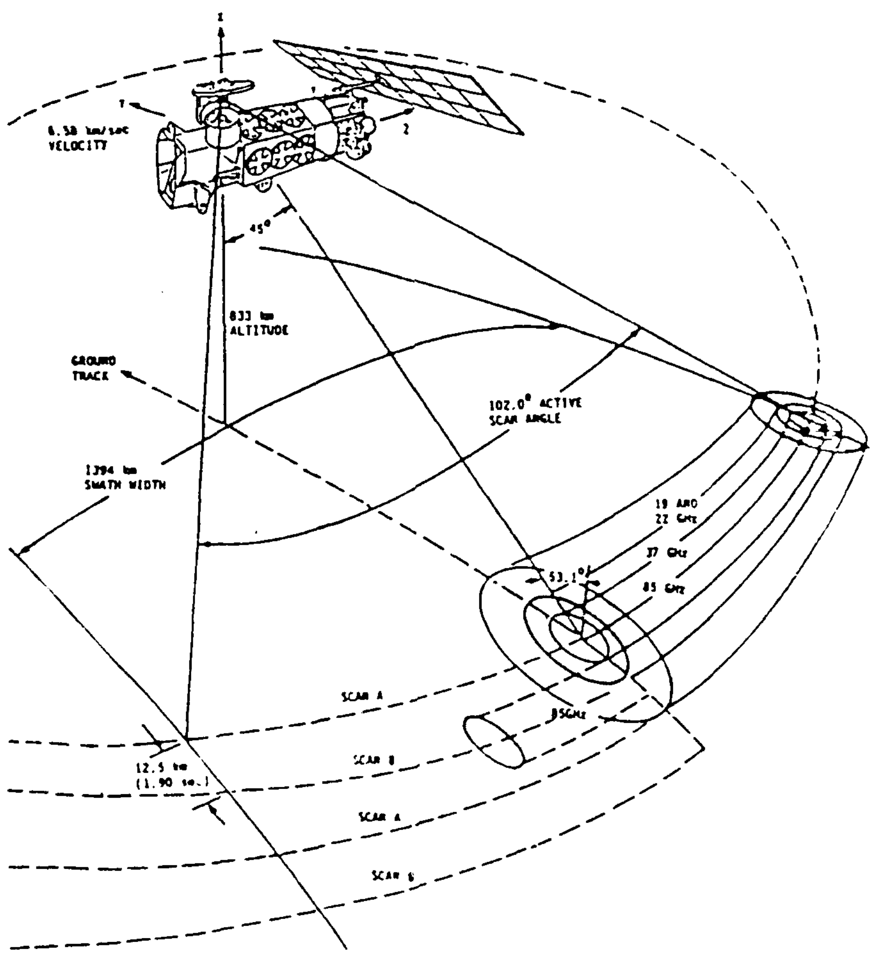
   d) **Swath width** is 1400 km, angular sector of 102.4 degrees

   e) **Scan period** is 1.9 seconds, sub-satellite point travels 12.5 km

   e) **Resolution** is 25 Km (12.5 Km for 85 GHz).

   f) **Samples:** 128 discrete samples per scan for both 85 GHz channels
   64 discrete samples on alternate scans for others

FIGURE 3.0-3 ACTIVE SCAN GEOMETRY



2) Calculates Sensor Data Records (SDR's): Kelvin

a) **Earth Located:** Geodetic latitude/longitude coordinates, oblate spheroid, LaGrange interpolation algorithm.

b) **Surface Tagged:** Latitude/longitude look up table; ocean, land, coast, and ice

c) **Calibrated:** Channel radiometric voltages, cold and hot temperature voltages, linear voltage to temperature conversion

d) **Antenna Pattern Corrected:** Sidelobe contributions, Channel Selection Table

3) Calculates Environmental Data Records (EDR's)

a) Earth located values for specific environmental parameters

b) Dependent upon surface type

- **Ice:** Ice age, Ice Edge, Ice Concentration
- **Land:** Rain Rate, Soil Moisture, Surface Type, Surface Temperature Snow Depth
- **Ocean:** Surface Wind, Rain Contamination, Rain Rate, Cloud Water, Water Vapor
- **Coast:** None

c) **Surface Types:** Land, Vegetation, Arctic, Ice, Possible ice, Ocean, Coast, Flooded soil, Dense vegetation, Land, Dry arable soil, Moist arable soil, Desert, Rain over vegetation, Rain over soil, Composite water and vegetation, Wet soil, Dry snow, Wet snow, Refrozen snow

SPECIAL SENSOR MICROWAVE TEMPERATURE SOUNDER (SSM/T-1)

1) **Passively collects microwave energy**

a) **Seven Channels**: in oxygen absorption band

Channel	Peaking Height (km)	Frequency (GHz)	Bandwidth (MHz)
1	0	50.5	400
2	2	53.2	400
3	6	54.35	400
4	10	54.9	400
5	30	58.4	115
6	16	58.825	400
7	22	59.4	250

b) **Scan Type:** Spin scan, cross-track nadir

c) **Positions:** Seven cross-track, two calibration (hot and cold)
0, +/- 12, +/- 24, and +/- 36
total 32 seconds, 2.7 second dwell time cross-track

e) **Resolution:** 174 km, 185 km, 220 km, and 304 km (view angle dependent)

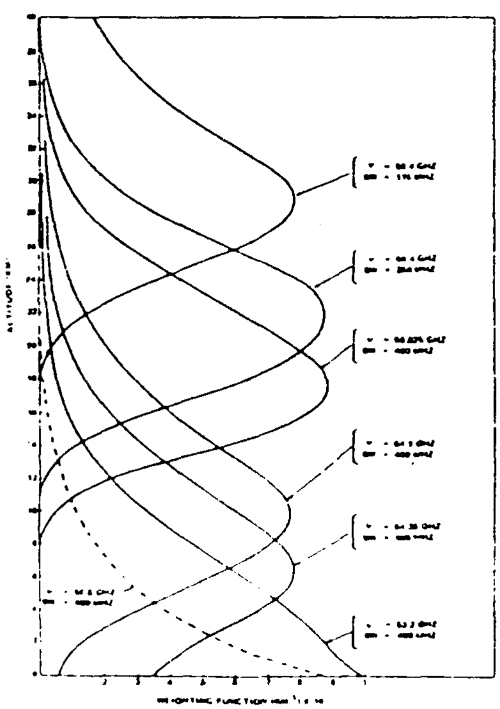


Figure D-1. $\theta = 0^{o}$, Calm Sea Background

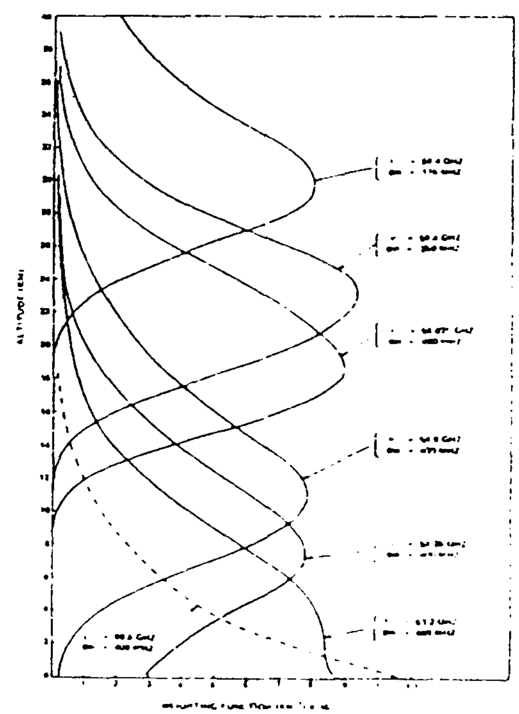


Figure D-2. $\theta = 41.67^{o}$, Calm Sea Background, Horizontal Polarization

2) Calculates Sensor Data Records (SDR's): Kelvin

a) **Earth Located:** Oblate spheroid, vector interpolation to obtain sub-satellite latitude/longitude.

b) **Calibrated:** Dicke radiometer; channel radiometric voltages, cold and hot temperature voltages (10 scan average), linear voltage to temperature conversion.

c) **Antenna Pattern Corrected:** Antenna temperatures multiplied by antenna pattern correction coefficients.

d) **Terrain and 1000 mb Heights:** Obtains values from database.

3) Calculates Environmental Data Records (EDR's)

a) **Precipitation Check:** Discards if channel 1 liquid precipitation threshold is exceeded over ocean.

b) **Terrain Height Corrected:** Corrects four lower channels to equivalent sea level brightness temperatures if terrain height exceeds 25 m.

c) **Multiple Regression for Fast Inversion:** less computational intensive

Linear relation between a parameter vector and a set of measured data,

$$\bar{p} - \langle p \rangle = D\,(\bar{d} - \langle d \rangle)$$

where the bar is estimate and the bracket is expected values

p = Atmospheric parameter vector (31)
d = Measured data vector (8)
D = Rectangular 31 X 8 matrix. Determined by minimizing the expected value of the square of the difference between the predicted vector and the true vector. Stratified by season, zone, and view.

- **Air Temperature:** 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, and 10 mbs

- **Atmospheric Thickness:** 1000-850, 850-700, 700-500, 500-400, 400-300 300-250, 250-200, 200-150, 150-100, 100-70, 70-50, 50-30, 30-20, 20-10 mbs

- **Tropopause Temperature and Pressure**

d) **Atmospheric Heights:** Stacks the thickness values on retrieved 1000 mb height from HIRAS. 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, 10 mbs

4) Verification and Matrix Update

a) **Residual errors** in the derived atmospheric profiles. Evaluates effectiveness of inversion matrix

- Bias and RMS statistics for latitude zone and pressure level
- Rawinsonde and rocketsonde data used as truth
- Rawinsonde collocates it within 3 hours and 100 Nautical miles (Nm)
- Rocketsonde used if within 9 hours and 200 Nm of rawinsonde
- Uses climatology above 10 mb if no rocketsonde is found

b) Sensor **random** and **bias** errors. Evaluates sensor performance and determine if an update is required.

- Coincident rawinsonde/rocketsonde and microwave measurements used to derive a data covariance matrix
- Compute error covariance matrices (sensor random and bias error)
- Estimate α and ß regression coefficients from DM (measured) and DC (calculated)
- If statistical tests are met, update the D inversion matrices

	90-N TO 60-N LAT.			60-N TO 30-N LAT.			30-N TO 00-N LAT.		
Level	Rpts	Mean	RMS	Rpts	Mean	RMS	Rpts	Mean	RMS
10 MB	484	-1.9	3.4	591	.3	5.0	134	1.4	3.4
20 MB	656	-1.8	3.0	1335	-1.3	3.2	384	.2	2.7
30 MB	721	-.6	2.0	1619	-.3	2.7	487	-.1	2.1
50 MB	811	.5	1.8	1801	-.1	2.5	552	.7	2.5
70 MB	863	.5	1.7	1886	-.2	2.6	596	1.8	3.4
100 MB	934	.4	1.6	2078	-.4	2.0	671	-1.8	3.1
150 MB	934	-.2	1.9	2078	-.6	2.4	671	-3.5	4.5
200 MB	934	-.7	2.7	2078	-.5	2.9	671	-1.8	3.3
250 MB	934	.0	2.4	2078	-.0	3.1	671	.2	2.2
300 MB	934	.0	2.5	2078	-.3	2.6	671	.5	2.1
400 MB	934	-.1	2.2	2078	.1	2.3	671	.5	2.1
500 MB	934	-.3	2.2	2078	.1	2.3	671	.7	2.0
700 MB	934	-.3	2.3	2063	1.5	2.9	671	.9	2.1
650 MB	909	-.5	3.3	2013	1.8	3.8	658	1.0	3.8
1000 MB	398	2.2	4.7	622	-.7	4.2	411	2.3	3.8

F-10 Error Stats 10 Apr. 92

1) **Passively collects microwave energy**

a) **Five Channels:**

183.310 GHz +/- 1	water vapor resonance line
183.310 GHz +/- 3	water vapor resonance line
183.310 GHz +/- 7	water vapor resonance line
150.000 GHz	low humidity channel
91.655 GHz	window channel

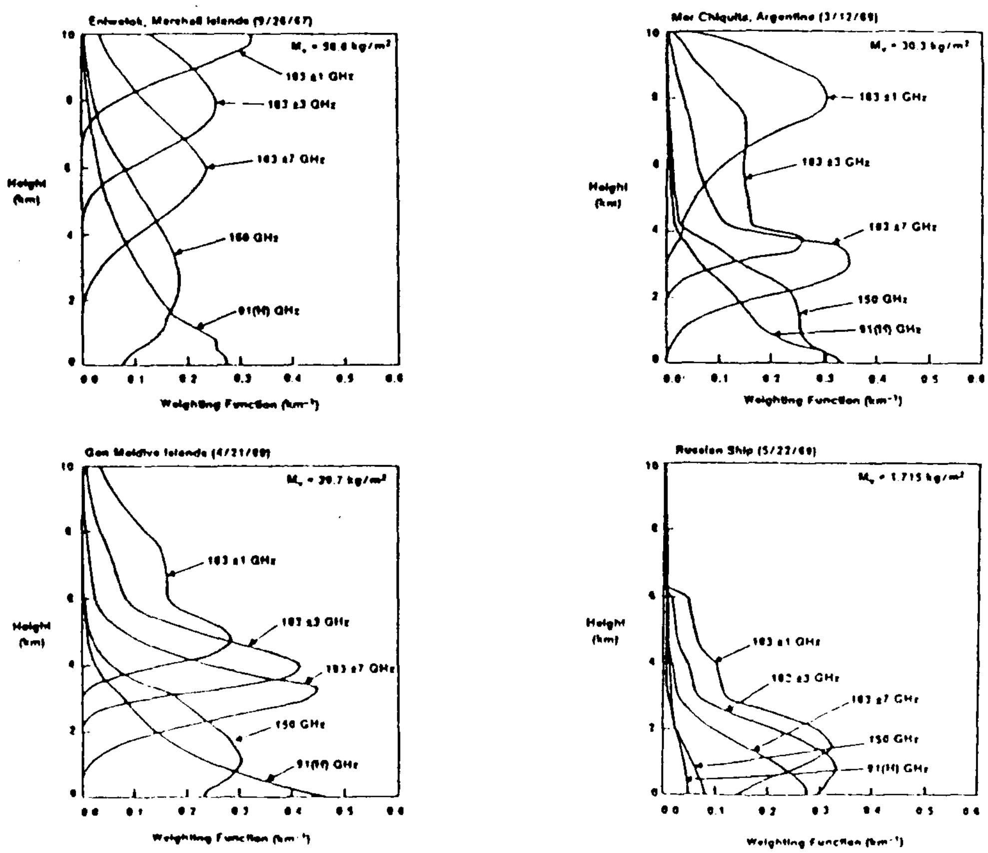
b) **Requires Four SSM/T-1 Channels:**

50.50 GHz	oxygen absorption
53.20 GHz	"
54.35 GHz	"
54.90 GHz	"

c) **Scan Type:** Spin scan, cross-track nadir, synchronized with SSM/T-1

d) **Positions:** 28 cross-track, four calibration (hot and cold)
View angles; 0 to 40.5 in 3 degree increments
Total scan time is 8 second

e) **Resolution:** 50 km at nadir through 75 km at view angle of 40.5



2) Calculates Sensor Data Records (SDR's): Kelvin

a) **Earth Located:** Accounts for earth rotation within 1 minute ephemeris block, ellipsoidal model replaced by exact geometry, adjustable reference height.

b) **Calibrated:** Total Power radiometer; channel radiometric voltages, cold and hot temperature voltages (8 scan average), linear voltage to temperature conversion.

c) **Terrain and 1000 mb Heights:** Obtains values from database and SSM/T-1

3) Calculates Environmental Data Records (EDR's)

a) **Terrain Height Corrections:** SSM/T-1 background effect correction, five reference heights (0, 1.5, 3.0, 4.5, 6.2 km), uses linear interpolation

b) **Inversion Method Based on Dynamic Stratification:** uses multiple linear regression, four background types (land, ocean, coast, ice) with stratification based on air mass characteristics (25), quality flag for wet profiles (.15 kg/m**2). Water vapor weighting functions show wide range of variability.

Background	Index	Air Mass
Ocean:	01 - 05	Vapor Mass, Cold, High Altitude Vapor
Land (0000 m):	06 - 08	Cold, High Altitude Vapor, Not
Land (1500 m):	09 - 11	"
Land (3000 m):	12 - 14	"
Land (6200 m):	18 - 20	"
Sea Ice:	21 - 22	Cold, Not
Coast:	23 - 25	Cold, High Altitude Vapor, Neither

c) **Relative Humidity:** 1000. 850, 700, 500, 400, and 300 mb levels in %

d) **Specific Humidity:** 1000, 850, 700, 500, 400, and 300 mb levels in G/KG

e) **Water Vapor Mass:** SFC-1000, 1000-850, 850-700, 700-500, 500-400, 400-300, and above 300 mbs in KG/M**2

USERS OF DMSP MICROWAVE RADIOMETER DATA

1) HIRAS: **High Resolution Analysis System**

- Provides initial conditions for GSM and RWM
- Uses SSM/T-1 temperature and height data
- Evaluation to incorporate SSM/T-2 moisture data

2) RWAM: **Relocatable Window Analysis Model**

- Planned to use both SSM/T-1 and SSM/T-2 profiles

3) ASPAM: **Atmospheric Slant Path Analysis Model**

- Uses SSM/T-1 temperature and height data
- Will incorporate SSM/T-2 moisture data
- Driving force behind SSM/T-2

4) RTNEPH: **Real Time Nephanalysis Model**

- Uses SSM/I data; SDR's for earth skin temperature

5) AGRMET: **Agricultural Meteorological Model**

- Uses SSM/I data; rain rates over land
- Interested in soil moisture

6) MISTIC: **Mission Sensor Tactical Imaging Computer**

- SSM/I imaging and fast EDR's
- Technique development and validation

7) SDHS: **Satellite Data Handling System**

- SSM/T-1 and SSM/I displays to enhance weather forecasts

8) GEON: **Global ETAC OL-A Network**

- Satellite transmission of databases to Asheville, NC

9) SSM/T-2 CAL/VAL: **SSM/T-2 calibration and validation study**

- Process real time SSM/T-2 for data collection
- Process other data sets required for validation

10) Tropical Forecast: **Tropical Storm fixing**

- Uses SSM/I data; rain rates and surface wind speed

11) Shared Processing: **Near real time transmission to FNOC and NOAA NESDIS**

- Raw data (prepfiles) SSM/I, SSM/T-1,and SSM/T-2

SPECIAL SENSOR MICROWAVE IMAGER SOUNDER (SSMIS)

1) **One sensor for temperature, thickness, moisture, and imaging**

a) **24 Channels:** Frequencies range from 19 to 183 GHz.

Channel	Frequency(GHz)	Polarization	Footprint(km)	Comments
1	50.3	H	37.7 x 38.8	Sounding LW
2	52.8	H	37.3 x 38.8	Sounding LW
3	53.596	H	37.7 x 38.8	Sounding LW
4	54.4	H	37.7 x 38.8	Sounding LW
5	55.5	H	37.7 x 38.8	Sounding L
6	57.29	V	37.7 x 38.8	Sounding L
7	59.4	V	37.7 x 38.8	Sounding L
8	150.0	H	13.2 x 14.7	Imaging
			37.7 x 38.8	Sounding W
9	183.31 +-.7	H	13.2 x 14.7	Imaging
			37.7 x 38.8	Sounding W
10	183.31 +-.3	H	13.2 x 14.7	Imaging
			37.7 x 38.8	Sounding W
11	183.31 +-.1	H	13.2 x 14.7	Imaging
			37.7 x 38.8	Sounding W
12	19.35	H	44.7 x 73.6	Imaging
13	19.35	V	44.7 x 73.6	Imaging
14	22.235	V	44.7 x 73.6	Imaging
15	37.0	H	31.2 x 45.0	Imaging
16	37.0	V	31.2 x 45.0	Imaging
17	91.655	V	13.2 x 14.7	Imaging
18	91.655	H	13.2 x 14.7	Imaging
			37.7 x 73.6	Sounding W
19	63.283 +-.285	H+V	75.2 x 75.0	Sounding U
20	60.792 +-.357	H+V	75.2 x 75.0	Sounding U
21	60.792 +-.359	H+V	75.2 x 75.0	Sounding U
22	60.792 +-.363	H+V	75.2 x 75.0	Sounding U
23	60.792 +-.373	H+V	75.2 x 75.0	Sounding U
24	60.792 +-.408	H+V	75.2 X 75.0	Sounding U
			37.2 x 38.8	Sounding L

c) **Scan Type:** 45 degree conical scan with concurrent beams

d) **Scan Rate:** 31.6 RPM, one revolution in 1.9 seconds

e) **Swath Width:** 143 2 degrees equals 1707 km

2) **Summary of Changes from Existing Sensors**: SSM/T-1, SSM/T-2, and SSM/I

a) **Earth Located:** Three reference heights, improved accuracy

- Environmental Data: 7 km at sea level
- Lower Air Sounding: 12.5 km at H = 11 km
- Upper Air Sounding: 12.5 km at H = 60 km

b) **Lower Air:** Temperature, thickness, water vapor

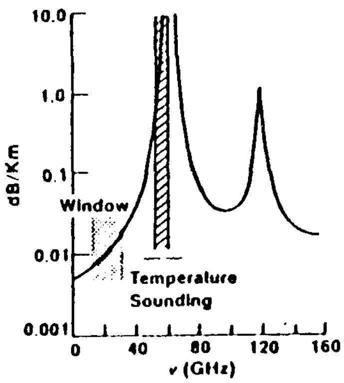
- Makes use of channels 18 (W) and 24 (T)
- Dynamic stratification uses tropopause pressure to choose between regression matrices
- Atmospheric thicknesses derived from hypsometric equation

c) **Upper Air:** Temperature, thickness (7, 5, 2, 1, 0.4, 0.2, 0.1, 0.03 mb)

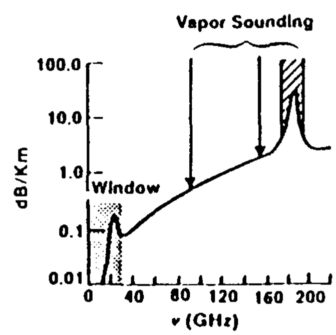
- Magnetic dipole moment of oxygen complicates radiative transfer (shifts weighting functions). Solar storms
- Doppler shift due to earth's rotation
- Instability of center frequencies (narrow band width)

d) **Imaging:** Similar environmental parameters and algorithms

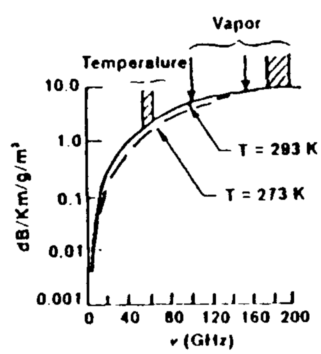
- Additional rainfall information from 150 GHz and 183 GHz
- Uses 91.65 GHz instead of 85.5 GHz



Absorption Coefficient Of Dry Air
(T = 293 K, Sea Level)



Absorption Coefficient Of Water Vapor In Air At Sea Level
(T = 293 K, ρ = 7.5 g/m³)



Absorption Coefficient Of Small Water Droplets

DMSP SPECIAL SENSOR MICROWAVE/IMAGER PROCESSING AT THE FLEET NUMERICAL OCEANOGRAPHY CENTER: OPERATIONAL STATUS, APPLICATIONS AND PLANS

Marie C. Colton and C. James Cornelius

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The most recent Defense Meteorological Satellite Program (DMSP) polar orbiting satellites have added a microwave component to their visible/infrared sensor suites by including a seven-channel, four frequency microwave radiometer, known as the Special Sensor Microwave Imager. Since 1987 and the launch of the first SSM/I aboard satellite F8, the Fleet Numerical Oceanography Center (FNOC) has had the responsibility of processing, assimilating and distributing the real-tme SSM/I data to the operational defense community. In addition, FNOC currently provides the data to the Naval Research Laboratory for subsequent archival at NOAA/National Environmental Satellite Data Information Service and use by the civilian research community. With the addition of the third SSM/I aboard satellite F11 in November, 1991 and the public release of the environmental data records from both satellites (summer, 1991), it is now possible for users to demonstrate the usefulness of global microwave data and assess its impact on operational meteorology.

The purpose of this paper is to provide a way point to current and potential users of the SSM/I data via an outline of the operational status of SSM/I data processing at FNOC. The computer platforms on which the data are received, processed and displayed are briefly described, as well as statistics and relevant information regarding the acquisition of the data thus far. Basic characteristics of the SSM/I software, delivered by Hughes Aircraft Company, including the algorithms by which microwave brightness temperatures are converted to geophysical parameters are listed. Standard daily products and applications which use the environmental parameters in both image and digital formats and the means by which these products are currently being communicated to regional sites are described. The development of new applications of SSM/I data is predicated on the amount of data sharing that occurs; therefore, near-term and future methods of data communications are discussed. The paper concludes with a discussion of planned improvements and future goals of the SSM/I processing at FNOC.

FNOC SSM/I Processing :
Status, Applications, and Plans

Mission Objectives

Operations Focus

Processing and Display Hardware

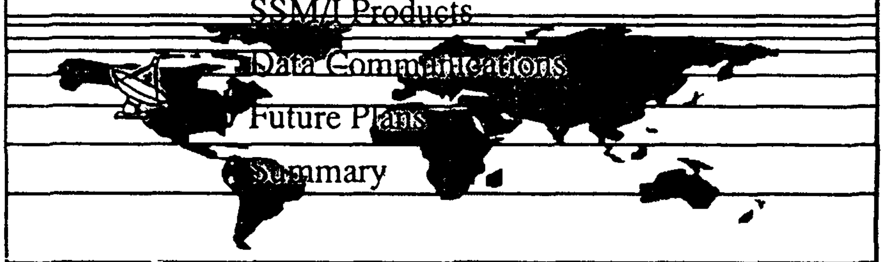
Ground Processing Software

SSM/I Products

Data Communications

Future Plans

Summary



Mission Objectives

- Provide operational Navy users with global, environmental products from the DMSP SSM/I
- Provide SSM/I brightness temperatures and environmental data records to the Shared Processing Network (SPN) partners, as set forth in the SPN MOA of 18 Jun 1984

MCC 14 Apr 92

Applications, and Plans

Daily Operations

- EARLY ORBIT SUPPORT (as required)
- INPUT
    - Complete acquisition of F10 & F11 DMSP SSM / I & OLS
- PROCESS
    - Benchmark SSM/I software and algorithms
    - Accurate geolocation: onboard ephemeris (7km)
    - SSM/I Software Configuration Management
- OUTPUT
    - Daily tape archival to NESDIS via NRL (5/day)
    - Digital data to CNODDS (NOAA, Monterey)
    - Ice concentration product to JIC/NPOC
    - Wind speed to Navy Op. Global Atm. Pred. Sys. (NOGAPS)
    - Integrated water vapor to moisture analysis
    - Imagery extractions from "Quadsphere" data base
    - Shared Processing Network transmissions

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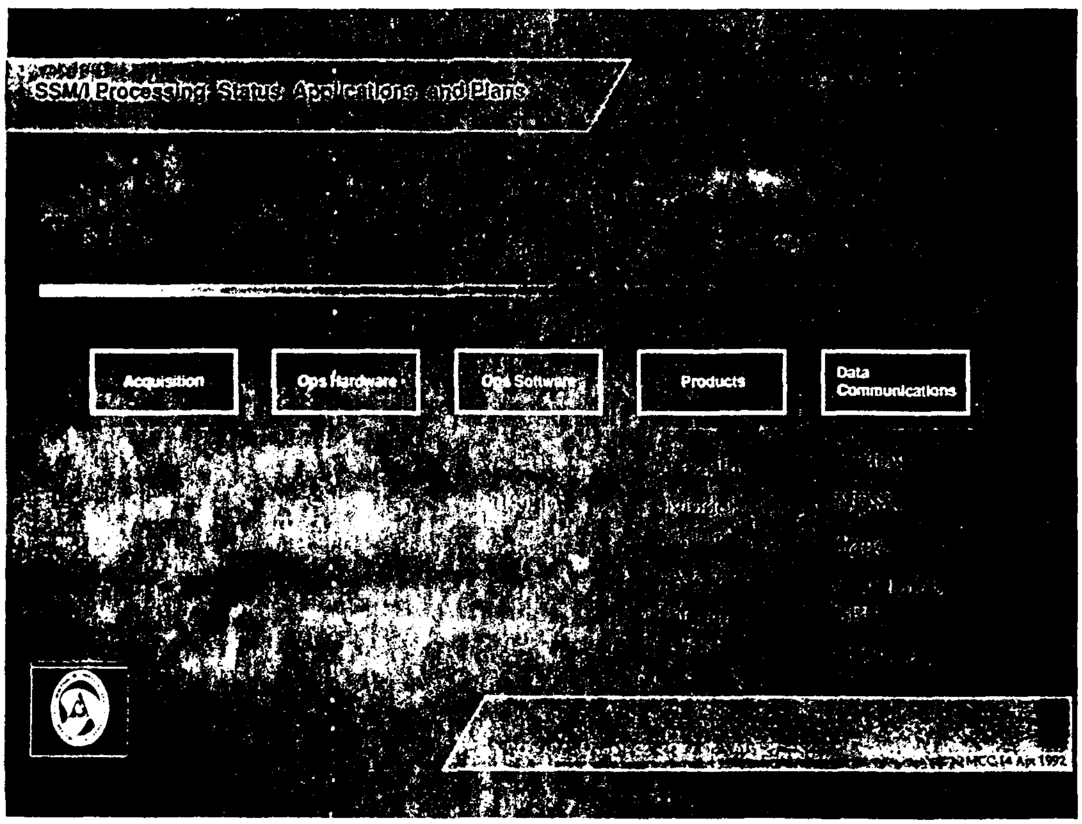
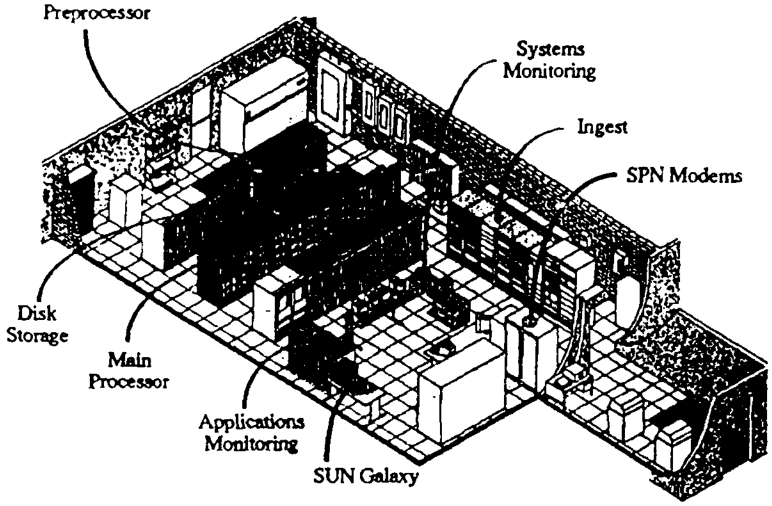


Satellite Processing Center



Operational Software Status

- Software updated to include final changes recommended by DMSP SSM/I Cal/Val team in their Final Report Vol II, May 1991
- Changes incorporated into FNOC and AFGWC software by Hughes programmers via direction from System Program Office, after formal recommendation from NRL.
- Installed on 3 Dec 9, effective with F10 #5251 and F11 SSM / I power-up
- Copied to SUN for Source Code Configuration System
- Updates pending: SPN file selection and Small Area transmits to regional centers

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Data Communication Networks

- Navy Environmental Data Network (NEDN)
  - Four-bit images at 9.6Kbaud
  - Transmitted to Regional Centers at Guam, Pearl Harbor, Norfolk, Suitland and Rota (Spain)
- Shared Processing Network for digital data sharing among FNOC, NOAA/NESDIS, AFGWC and NAVOCEANO (7 Jan 92)
- Digital files to Guam, Rota, NPOC via Defense Data Network

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Processing Plans

- Improve reliability of raw data acquisition phase
- Exploit move to Open System architecture hardware
  - Transfer data from Concurrent to Sun via LAN (TCP/IP)
  - Migrate SSM / I processing to Sun Galaxy
  - Store archival data sets on optical discs
- Turnover operational data archival responsibility to NOAA

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Product Development

- Subarea digital files in standard format (eg., BUFR)
- Graphic plots : ice concentration values
- Contour plots : 30 kt wind radius
- Multiplexed images and conditional extractions
- Simplified SDR and EDR files
- Expanded data base : land parms to model input files
- Rain "Index" field
- Moisture input to NOGAPS (NRL)

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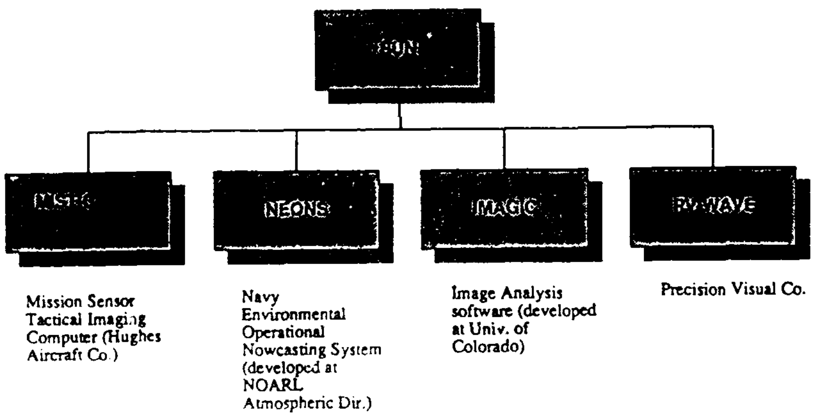
SUN Hosted Applications



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NODDS vugraph

Processing Status, Applications and Plans

ISSUES

- SSM / I Configuration Management
- Mechanism for evolution of processing software and algorithms
- NESDIS / NGDC Archival
- SPN automation enhancements (polling v. windowing)

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Summary

- FNOC processes all SSM / I data from two DMSP Satellites (F10 and F11)
- The operational software uses the most current algorithms as specified in the DMSP Cal / Val Report, Vol II (1991)
- The benchmark software is under version control at FNOC
- Standard products include wind speed assimiliation by NOGAPS
- SPN transmits occur 24 hr/day
- Data archival to tape continues
- Current emphasis at FNOC is on improvement of graphic displays and SSM / I data communications, including SPN

AN OVERVIEW OF THE EXPERIMENTAL SSM/I ORBIT-BY-ORBIT PRODUCTS SYSTEM (SSMIPROD) AT NOAA/NESDIS

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Landover, MI 20745-2224

A prototype products system for deriving experimental SSM/I orbit-by-orbit products (SSMIPROD) has been developed at NOAA/NESDIS. SSMIPROD was developed to obtain a better understanding of the accuracy of the SSM/I geophysical algorithms, to enhance the reliability of pre-launch algorithms being developed for the Advanced Microwave Sounding Unit (AMSU), and to gain experience in delivering microwave products to NOAA users such as National Weather Service/National Meteorological Center/Development Division (NWS/NMC/DD).

SSMIPROD has been running in a routine "experimentally operational" environment since July 26, 1990. The SSMIPROD output file contains two days of SSM/I orbit-by-orbit products stored in a rotating direct access file on the NOAA HDS computer. Currently, there are 11 products (six ocean, three sea ice, and two land) being generated by SSMIPROD. The ocean products include the output of two precipitation algorithms, two near surface wind speed algorithms, and two total precipitable water (TPW) algorithms. The sea ice products include the output of total ice concentration from three sea ice algorithms. The land products include the output from two precipitation algorithms.

Extensive analysis and evaluation of these products has been performed at NOAA/NESDIS. A plan for the validation of the products was developed to test and evaluate the quality of the orbit-by-orbit products more completely. This plan involves using many independent data sets as "ground truth" for validating the products. In this paper the validation of the TPW algorithms using matched radiosonde data will be discussed. The quality of the precipitation algorithms will also be discussed.

OUTLINE OF TALK

1. Overview/History of SSM/I Processing at NOAA/NESDIS

2. Data Flow: SSM/I Products

3. Current SSM/I Orbit-by-Orbit (SSMIPROD) Products

4. SSMIPROD Products/Images

5. Summary/Plans/Related Talks

History of SSM/I processing at NOAA/NESDIS

- NESDIS - has a shared processing agreement Air Force, Navy

- NESDIS COE for Polar/DMSP Soundings

- NESDIS Office of Research and Applications (ORA) receives raw SSM/I data near real time from AFGWC (Orbit-by-Orbit) for **Sounding Improvement**

- NESDIS creates an SSM/I-1b data set with earth located radiances (since 1989)

- SSMIPROD (Orbit-by-Orbit) SSM/I Products - Running "Experimentally" since July 26, 1990

- SSMIPROD developed to evaluate SSM/I Cal/Val algorithm products prior to routine availability from FNOC

- MASTERMAPS - mapped SSM/I products (512 X 512 (1/8th mesh)), (1024x1024 (1/16th mesh)) - polar stereographic

CURRENT "EXPERIMENTAL" PRODUCTS (F-10 and F-11)

OCEAN

PRODUCT #	
1	**WIND SPEED (CAL/VAL)**
2	TEST GOODBERLET WIND SPEED (CAL/VAL)
3	**TOTAL PRECIPITABLE WATER (CAL/VAL)**
4	TOTAL PRECIPITABLE WATER (PETTY)
5	RAIN RATE (GRODY)
6	**RAIN RATE (CAL/VAL)**

LAND

PRODUCT #	
1	**RAIN RATE (CAL/VAL)**
2	RAIN RATE (GRODY)
3	Not Used
4	Not Used
5	Not Used
6	Not Used

ICE

PRODUCT #	
1	**CAL/VAL ICE CONCENTRATION**
2	**CAL/VAL ICE TYPE**
3	GRODY ICE CONCENTRATION
4	NASATEAM TOTAL ICE CONCENTRATION
5	NASATEAM FIRST YEAR ICE CONCENTRATION
6	NASATEAM MULTI YEAR ICE CONCNETRATION

Ocean: Wind Speed (m/sec):

Cal/Val: Linear 19V,22V,37V,37H Tb (quality flags)

Tb's

Quality Flags

range: 1-25m/sec

Test Cal/Val: Similar to Original Cal/Val

Weather Filter (developed for Typhoon Wind Speeds)

Quality Flags

Ocean: Total Precipitable Water TPW (mm):

Cal/Val: Non-Linear (exponential) 19V, 22V, 37V

Tb's

range: 10mm-60mm

TPW=232.89-0.148*Tb19V-1.829*Tb22V-0.369*Tb37V-0.006193*Tb22V**2

SSMIPROD Ice Products

General:

- All % < 0 set to 0; all % > 100 set to 100
- Flags: 0 - 25%-100%
  1 - 0%-25%
  7- < 0% or > 100%
- Climatological Ice Limit (current vs. latest JIC (G. Wohl))

Ice Products

1. **Navy Cal/Val Ice Concentration:**

    - Linear (19V, 19H, 37V, 37H)
    - Winter and Summer Coefficients
    - % Ice Concentration (25%-100%), Ice Type (Fyr, Myr)

2. Grody Ice Concentration

    - Emissivity based Linear (19V, 22V)
    - Variable Emissivity Threshold = 0.7 (current)

3. NASATEAM Ice Concentration

    - Linear (19V, 19V, 37V)
    - Tie Points (winter, summer) - Open water, ice covered, Gradient Ratio (weather filter)
    - Total, Firstyear, Multiyear (%)

Grody Decision Tree Algorithm

- Non-Linear (19V, 19H, 22V, 37V, 85V)
- SI85 and SI37 (If SI37 + 3 > SI85 use SI37)
- 85GHz Precipitation (rain rate mm/hr) Ocean and Land
- Snow Cover Index (Land)
- Desert Sand (screened out)
- **Vast improvement over 37GHz algorithms (especially over land)**

SUMMARY/PLANS:

- Two "Experimental" SSMIPROD data sets: F-10 and F11
- FNOC data (EDR's) Primary Source of SSM/I data 1992 (reformat)
- AFGWC SSM/I data will be used as a backup
- Plans to make SSMIPROD/MASTERMAPS Operational:
    - Merge code, test products, Transfer to CEMSCS
- VALIDATION: Q.M. Winds already developed (continue), TPW, Precip, Snow Cover, Sea Ice

Related Talks (Users):

- "Real Time Quality Control of SSM/I Wind Speed Data" M. Waters W.S. Richardson, W.H. Gemmill, C.M. Caruso (NOAA) (SSMIPROD)
- "Uses of SSM/I Wind Speed data in Operational Numerical Weather Prediction System at NMC" T.W. Yu, W.H. Gemmill, J. Wollen (NMC/DD) (SSMIPROD)
- "Impact of SSM/I based Snow/Ice Analyses in NMC's Eta Model - K. Mitchell (NMC/DD) (MASTERMAP)

Related Talks (NOAA/NESDIS):

- Sea Ice and Wind Products Production and Evaluation - W. Pichel (SSMIPROD)
- Grody/Ferraro: Use of SSM/I for Precipitation at NOAA/NESDIS
- SSM/I MASTERMAP Products: D. Donahue C. Boettcher (SMSRC)
- Operational Plans for SSM/I PRODUCTS: P. Taylor

SSM/I MAPPED EXPERIMENTAL ENVIRONMENTAL IMAGE PRODUCTS

David R. Donahue and Corey M. Boettcher

S M Systems and Research Corporation
8401 Corporate Drive, Suite 510
Landover, MD 20785

Pamela M. Taylor and Norman C. Grody

NOAA/NESDIS
Washington, DC 20233

Globally mapped experimental image data of snow cover, sea ice, precipitation scattering, rain rate, and total precipitable water, derived from the Special Sensor Microwave/Imager (SSM/I), are now updated on a daily basis at NESDIS. NESDIS receives the SSM/I data in near real time via the Shared Processing Network between NESDIS, the Navy, and the Air Force. This data is available to NOAA users on the HDS computer facility in the form of 1B data sets, which include earth-located raw counts and calibration parameters, produced as soon as the orbital data are received at NESDIS. Once transferred to the HDS system, each SSM/I 1B data set is calibrated and an Intermediate Data Base (IDB) of antenna temperatures is generated. The data in the IDB is then processed by the DMSP SSM/I Master Maps software, which provides gridpoint analyzed fields of SSM/I channel measurements and derived products for access by users.

SSM/I MAPPED EXPERIMENTAL ENVIRONMENTAL IMAGE PRODUCTS

Corey M. Boettcher and David R. Donahue
S M Systems and Research Corporation
Landover, Maryland

Pamela M. Taylor
Norman C. Grody
NOAA / NESDIS
Washington, D.C.

OVERVIEW

- NOAA/NESDIS receives SSM/I data in near real-time, currently over the Shared Processing Network from Air Force Global Weather Central.

- The Sounding Implementation Branch (SIB) has developed the Experimental DMSP SSM/I Master Maps Image Product System as part of an effort to use SSM/I data to improve the DMSP SSM/T temperature soundings. This work also enhances the ability of NESDIS to process and distribute the Fleet Numerical Oceanography Center SSM/I products.

- As each SSM/I data set is received and processed, SIB has automated software which computes and maps environmental products. These products, along with the antenna temperatures and time-identifying parameters, are written as image pixel values onto individual gridded polar-stereographic fields.

- The image files containing these gridded fields are accessible on the NESDIS mainframe to all interested users. Testing of these experimental products has shown their usefulness in improving SSM/T soundings and in many other weather and climate studies.

- As a result of the interest in these experimental SSM/I products, SIB has received formal requests from the National Meterological Center, the National Hurricane Center and the Navy/NOAA Joint Ice Center for operational access to these products. Work is underway to make these experimental SSM/I Master Maps products operational.

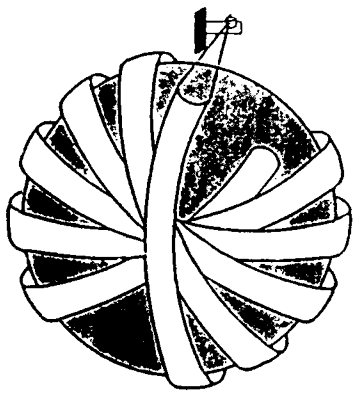
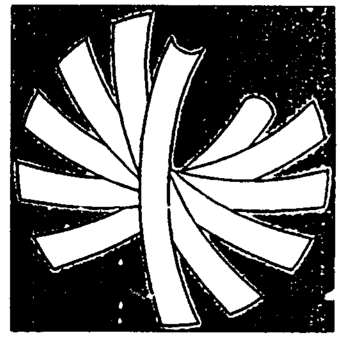


Diagram of
SSM/I Data
As Recorded By
DMSP Satellite



Resulting DMSP
SSM/I Master Maps
Polar-Stereographic
Image

DMSP SSM/I MASTER MAPS IMAGE FILES

One Image File	Per Hemisphere
	Per Resolution
	Per Satellite

MAPPED RESOLUTIONS

1/8th Mesh

512 X 512 Pixel

47.6 km @ ±60° latitude

Satellites: F-8 (no 85 GHz)
F-10
F-11

1/16th Mesh

1024 X 1024 Pixel

23.8 km @ ±60° latitude

Satellites: F-10
F-11

FILE STRUCTURE

MAPPED SSM/I PARAMETERS IN EACH IMAGE FILE

		ALGORITHM
CURRENT;	Channel Antenna Temperatures	
	Latitude & Longitude of source data for each pixel	
	Time-Identifying Information (i.e. Julian Day & GMT)	
	Solar Zenith Angle	
	Snow Cover Scattering Index	N. Grody
	Sea Ice Concentration	Navy Cal/Val
	Precipitation Scattering Index; Land & Ocean	N. Grody
	Precipitation Rain Rate; Ocean-Only	N. Grody
	Total Precipitable Water	Navy Cal/Val
FUTURE;	Sea Ice Concentrations: Total, Multi-year & First-year	NASA team
	Precipitation Rain Rate; Land & Ocean	N. Grody
	Surface Wind Speeds	Navy Cal/Val

SUMMARY

- The development of the DMSP SSM/I Master Maps products has proven to be excellent preparation for the NESDIS processing and distribution of FNOC SSM/I products.

- The experimental SSM/I Master Maps products provide a unique troubleshooting ability for both science and software development. As a result, NESDIS could potentially provide science support to FNOC products.

- Progress continues on using the mapped SSM/I products to improve SSM/T soundings.
    - Testing will soon begin using the SSM/I Master Maps sea ice product as a dynamic ice field within the DMSP SSM/T sounding system, thus replacing a static ice field.
    - Work is ongoing to use the mapped SSM/I channel antenna temperatures to aid in applying surface corrections to the SSM/T channels.

For details on how to access these experimental SSM/I Master Maps products or for further information, please feel free to contact:

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(301) 763-4384

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(301) 763-4380 / FAX: (301) 420-0932

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SSM/I TOTAL PRECIPITABLE WATER VAPOR ALGORITHMS: A REPRISE AND UPDATE

J.C. Alishouse and R.R. Ferraro

NOAA/NESDIS
Satellite Research Laboratory
Washington, DC 20233

This presentation will provide a brief review of the development of the present operational total precipitable water (TPW) algorithm and the compilation of the data base used to develop and validate it. Other algorithms for the SSM/I TPW have been developed and published. Brief comparisons between the various algorithms and the validation data base will be made. A continuing and real time validation and quality control effort for water vapor algorithms is being implemented as part of the experimental products development. Factors of relevance to future algorithm and instrument development will be presented.

SSM/I TOTAL PRECIPITABLE WATER ALGORITHMS:
A REPRISE AND UPDATE

JOHN C. ALISHOUSE

AND

RALPH R. FERRARO

NOAA/NESDIS
SATELLITE RESEARCH LABORATORY

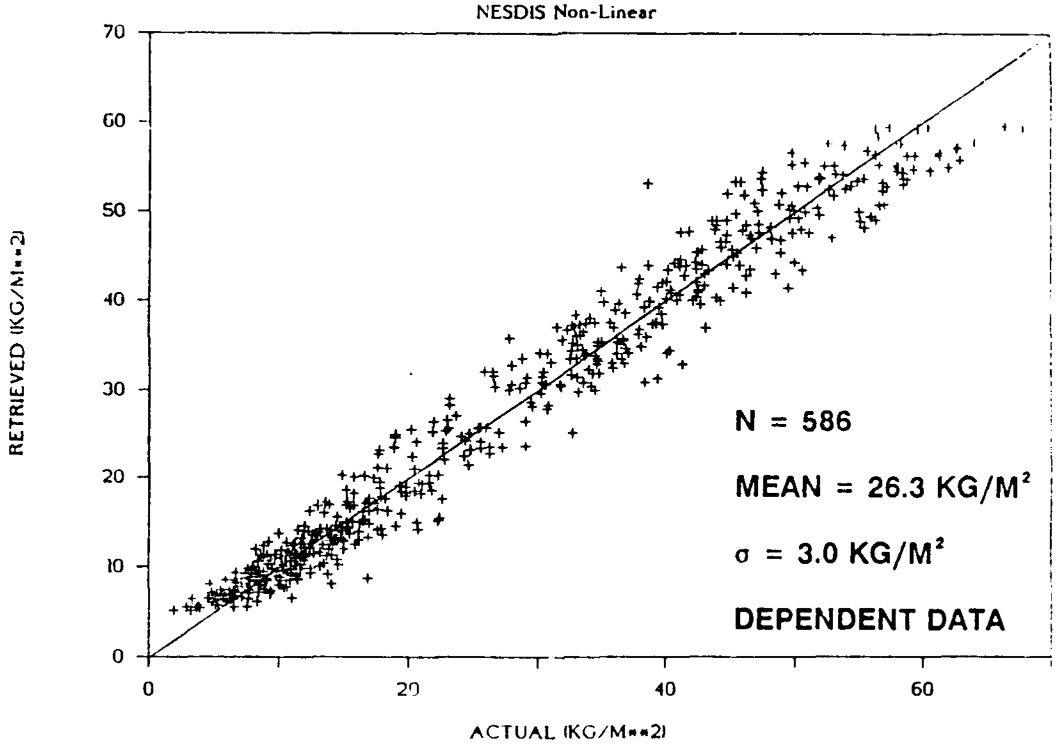
PRESENTATION AT:

DMSP RETRIEVAL PRODUCTS WORKSHOP

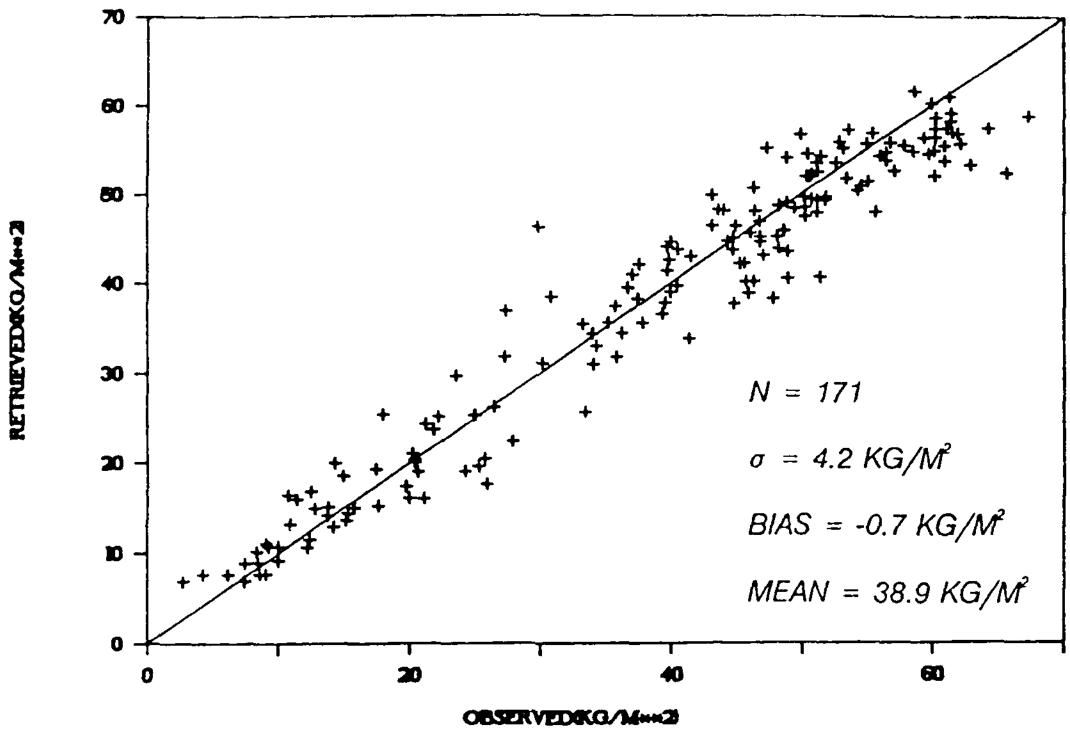
APRIL 14, 1992

SSM/I TPW vs. RAOB

NESDIS Non-Linear

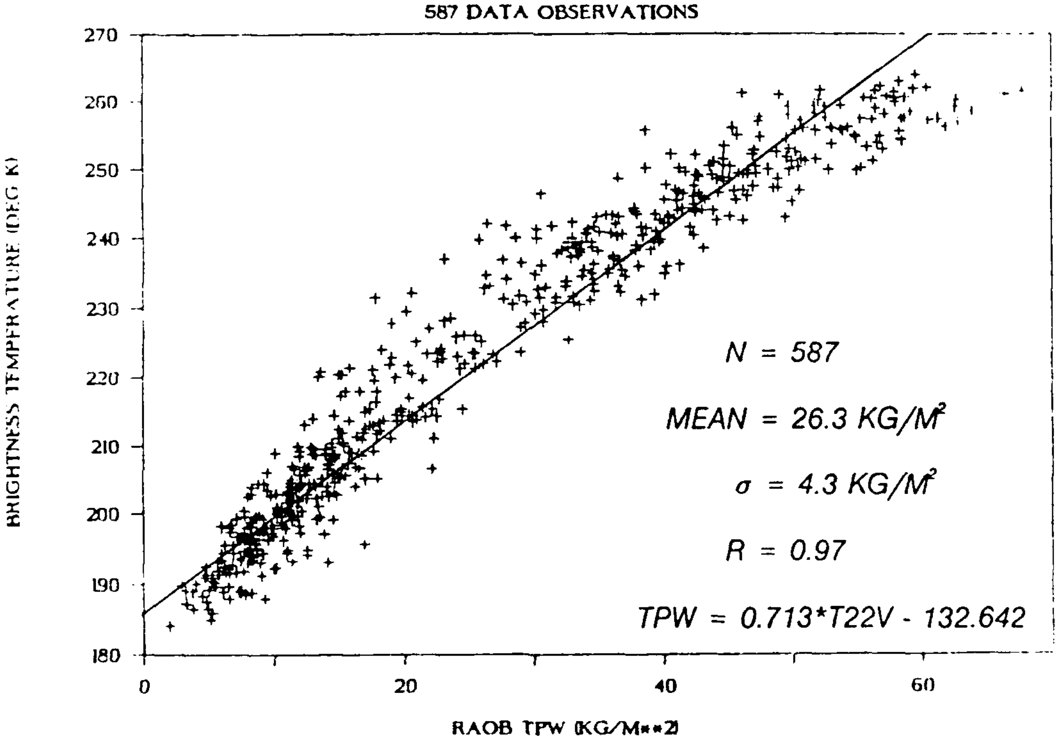


INDEPENDENT DATA SET

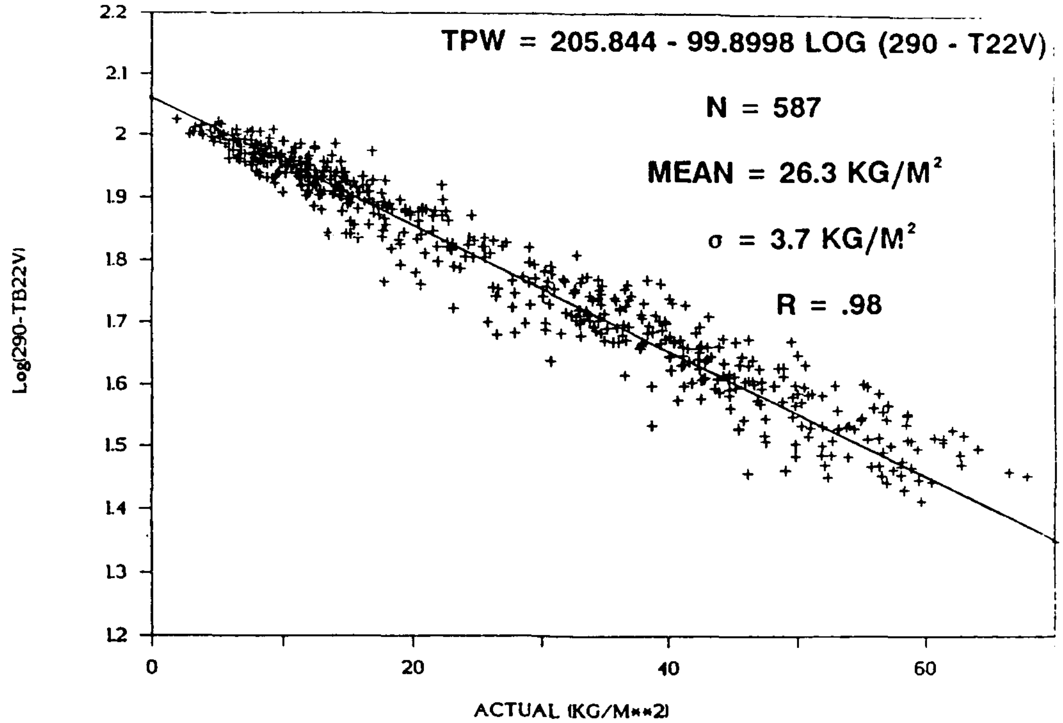


SSM/I TB(22V) VS. RAOB TPW

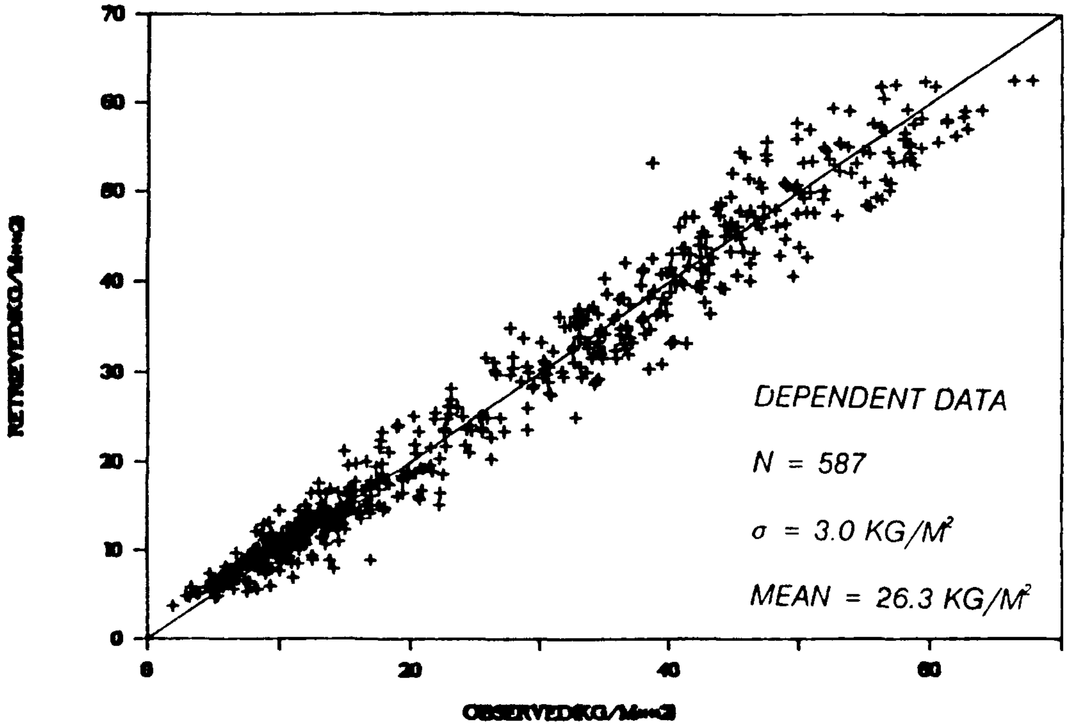
587 DATA OBSERVATIONS



Log(290-TB22V) vs. RAOB



LOGARITHMIC ALGORITHM



SET	N	MEAN (KG/M²)	RMSD (KG/M²)	PCTD	BIAS (KG/M²)
T SQUARED ALGO					
DEP	586	26.3	3.0	11.4	0
IND	171	38.9	4.2	10.8	-0.7
T_B^{22V} ONLY					
DEP	587	26.3	4.3	16.3	0
LOG (290 - T_B^{22V})					
DEP	587	26.3	3.7	14.1	0
4 LOG VARIABLES					
DEP	586	26.3	3.0	11.4	0
IND	171	38.9	4.3	11.2	-0.4

$$TPW = A_0 + A_1 * T_B^{19}V + A_2 * T_B^{22}V + A_3 * T_B^{37}V + A_4 * (T_B^{22}V)^2$$

$$TPW = B_0 + \sum B_I * LOG(290 - T_B^I)$$

ISSUES FOR FURTHER STUDY

o FREQUENCY OF WATER VAPOR CHANNEL

REDUCED SENSITIVITY AT LARGE TPW AMOUNTS

CHANGE? IN CONE ANGLE FOR SSM/IS-2

PRESSURE BROADENING EFFECTS AT LINE CENTER

SMMR AND AMSU-A WORK OFF LINE CENTER

S/N CONSIDERATIONS

o VALIDATION AND QC OF ALGO RESULTS

DOES F8 ALGO WORK FOR F10 AND F11?

QC FOR RESULTS

SUMMARY

o NEED WATER VAPOR CHANNEL

o RETRIEVALS OF LARGE WV AMOUNTS (SATURATION)

o VALIDATION AND QC FOR NEW INSTRUMENTS

THE USE OF THE DMSP SSM/I FOR THE GENERATION OF PRECIPITATION PRODUCTS AT NOAA/NESDIS:

PART I: A STATUS REPORT

PART II: SCIENTIFIC RESULTS

Norman C. Grody and Ralph R. Ferraro

NOAA/NESDIS
Satellite Research Laboratory/Land Sciences Branch
Washington, DC 20233

The demand for precipitation measurements from satellites ranges from instantaneous rain rates in support of operational weather and hydrological forecasts to weekly or longer rain accumulations for agricultural and climate monitoring needs. At NOAA, the demand for these measurements comes from several divisions of the National Weather Service and the National Environmental Satellite, Data, and Information Service. To support this demand, there are presently several activities ongoing at the Satellite Research Laboratory using SSM/I measurements to generate experimental precipitation products.

The activities can be categorized as the following:

(1) SSM/I rain retrieval algorithm development and evaluation
(2) Algorithm calibration and verification
(3) Near real time rain product generation
(4) Applications for synoptic scale processes
(5) Applications for climate scale processes
(6) Applications for numerical weather prediction

It is the purpose of the first presentation to discuss the objectives, current status, and future plans of these activities. The second presentation will discuss some of the key scientific issues and current results of these projects.

The Use of the DMSP SSM/I for the Generation of Precipitation Products at NOAA/NESDIS: Part I - A Status Report

Ralph Ferraro

Norman Grody

Summary of SSM/I Rain Activities

1. "Experimental Operational" Activities

   o Orbit by Orbit Products

   o Mapped Products

   o VDUC Products

   o Level 1b Case Studies

2. Research Activities (in support of Climate and Global Change)

   o Algorithm Development/Improvements

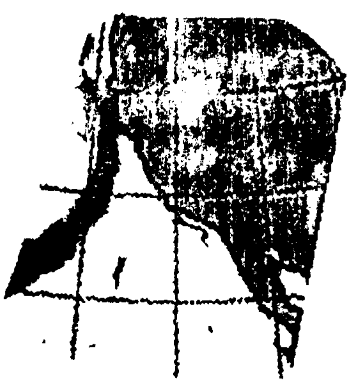
   o Algorithm Calibration

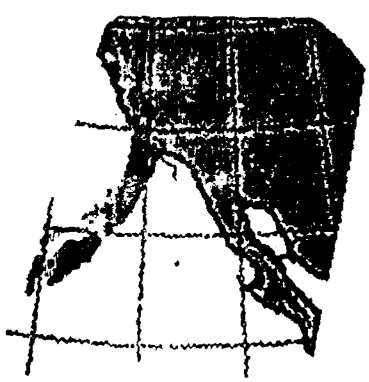
   o Algorithm Intercomparisons

   o Climate Products

VAS Data Utilization Center (VDUC) Products

1. Composite product files (F-11) generated every 6 hours
   - o Whenever the computers co-operate!
   - o Ocean - Winds, Rain Rate (37 GHz), Sea-ice
   - o Land - Rain Rate (37 GHz), Snow Cover, Surface "roughness"
   - o 24 hour rotating file
2. Used by:
   - o NESDIS/SAB - support operational rain fall forecasts
   - o ORA - in-house R&D
   - o NHC - wind fields and storm centers
3. Future upgrades:
   - o Dual-satellite system
   - o 85 GHz algorithms





NESDIS Level 1b Data Sets

1. Used for in-house, near-real time algorithm evaluations

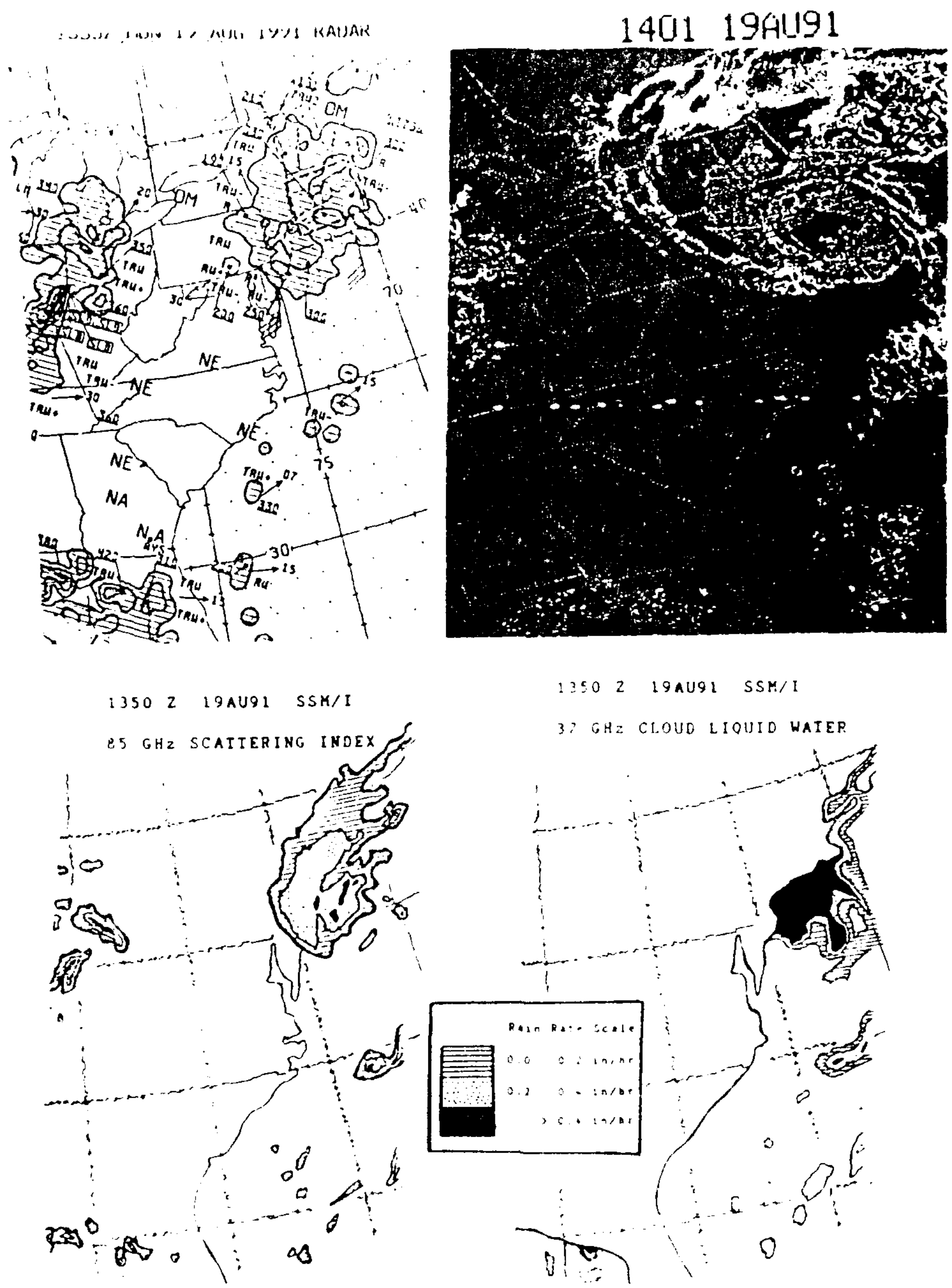
   o "Field Experiments"

   o "Independent" algorithm performance

   o SAB interactions

   o Extreme events investigations

2. Sensor status/intercomparisons (limited)

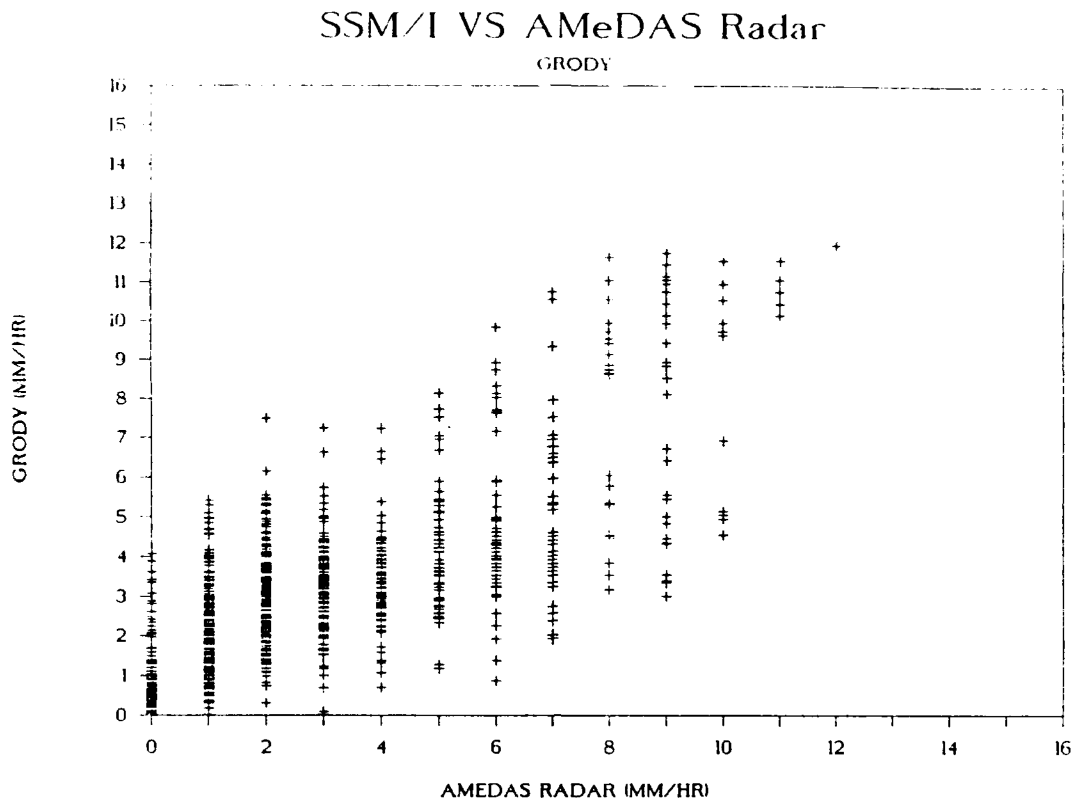


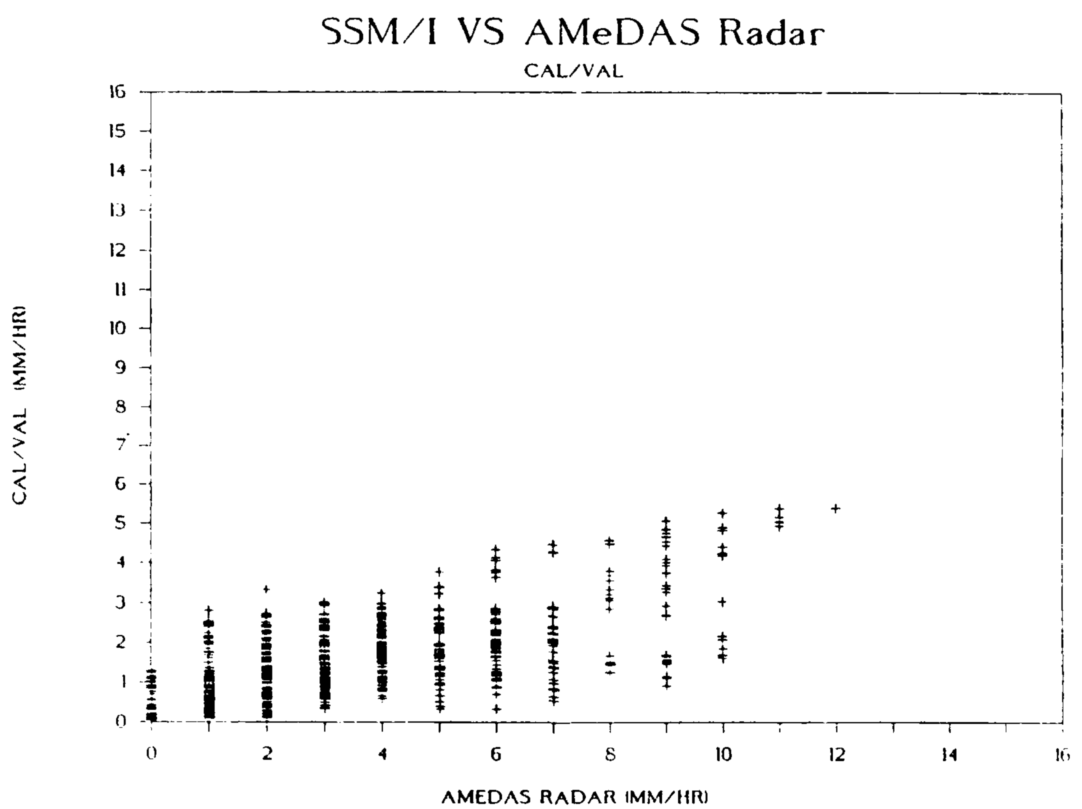
ALGORITHM DEVELOPMENT/IMPROVEMENTS

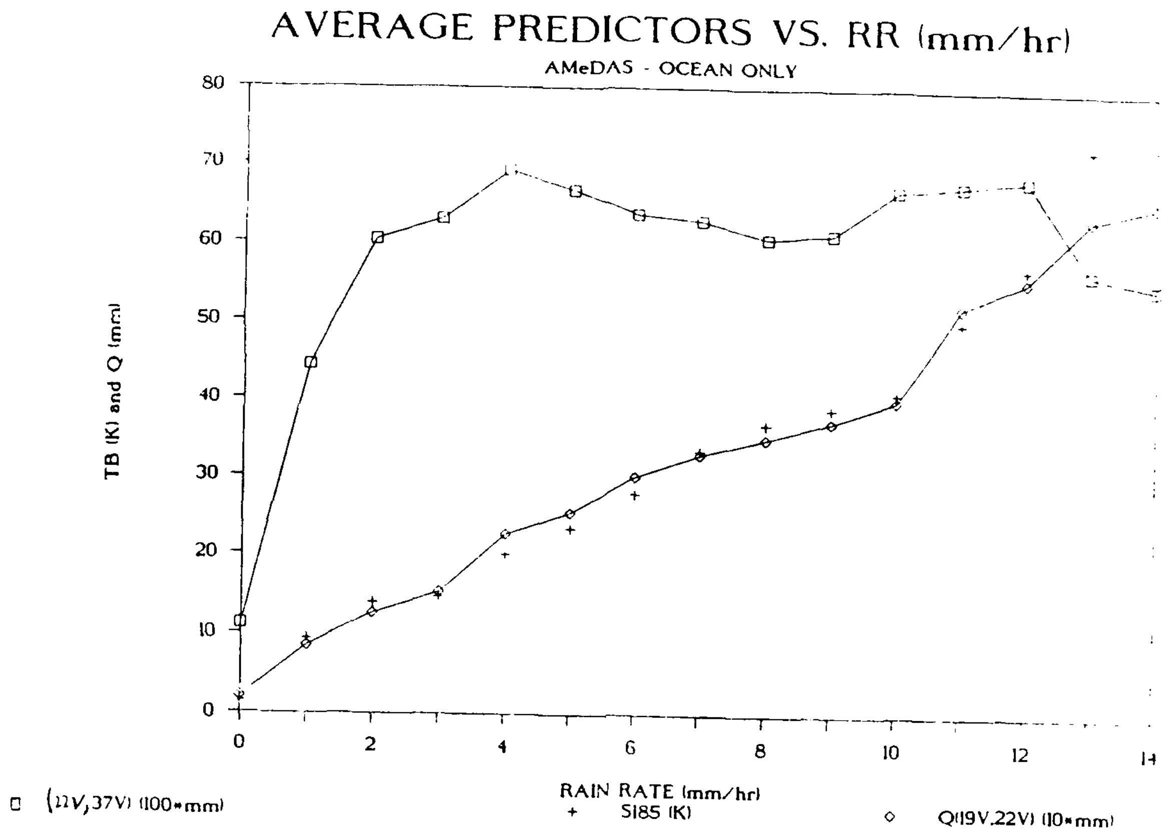
1. GRODY GLOBAL 85 GHz SCATTERING INDEX (SI)
2. SCATTERING VS. EMISSION OVER OCEAN
3. FREQUENCY VS. POLARIZATION (AMSU)
4. IFOV VARIABILITY IMPACT STUDIES
5. SI VARIABILITY WITH SENSOR AND GEOGRAPHY

ALGORITHM CALIBRATION

1. CO-INCIDENT SSM/I AND RADAR DATA SETS
   - o RADAP-II (NWS)
   - o AMEDAS (JMA)
   - o [TRMM/DARWIN (NASA)]
   - o [FRONTIERS (UK)]
2. PIXEL BY PIXEL VS. BINNING


SSM/I VS AMeDAS Radar
GRODY
GRODY (MM/HR)
AMEDAS RADAR (MM/HR)
0
2
4
6
8
10
12
14
16


SSM/I VS AMeDAS Radar
CAL/VAL
CAL/VAL (MM/HR)
AMEDAS RADAR (MM/HR)
0
2
4
6
8
10
12
14
16



Algorithm Intercomparisons for Climate

1. Create 3 year, monthly, climate scale (100 km) rain averages
2. Task supported by Phil Arkin for Remote Sensing Systems (Wentz)
3. Algorithms to be used:
   - o Grody 85 GHz SI
   - o Barrett/Kidd (Univ. Bristol)
   - o Petty/Olson (Purdue/Wisconsin)
   - o Adler (NASA)

Climate Products

1. Generate from retrospective data; to be placed on MO disks
2. Weekly, monthly, etc. for >5 years F-8 SSM/I
3. Prototypes from Grody SI now being generated from tape

PRODUCTION AND EVALUATION OF EXPERIMENTAL SSM/I ICE AND WIND PRODUCTS AT NOAA/NESDIS

William Pichel

NOAA/NESDIS E/RA13
Satellite Research Laboratory
NOAA Science Center Room 102
Washington, DC 20233

Ice and wind products are among the suite of products being routinely produced on an experimental basis from DMSP SSM/I data at NOAA/NESDIS. Each product is being produced from two or more algorithms to evaluate available algorithms as to their utility to operational ocean and atmospheric analysis and forecasting activities of the Navy/NOAA Joint Ice Center (JIC), the National Meteorological Center, and the NOAA Ocean Products Center.

Maps of ice concentration produced by three algorithms (Navy Calibration/Validation, NASA Sea Ice Working Group, and NESDIS/Norman Grody) are compared with operational JIC ice analyses produced using visible and infrared satellite imagery. Wind speed observations generated with two algorithms (Navy Calibration/Validation, and an improvement on that algorithm obtained from Mark Goodberlet) are evaluated using closely matched NOAA moored buoy wind reports.

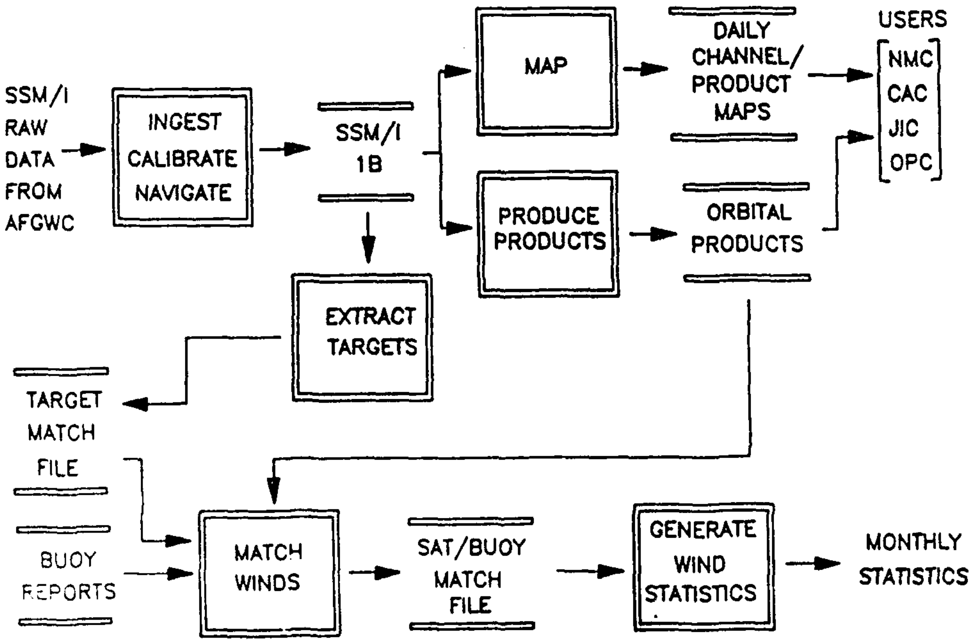
PRODUCTION AND EVALUATION OF

EXPERIMENTAL SSM/I ICE AND WIND PRODUCTS

AT NOAA/NESDIS

- o SSM/I ICE AND WIND PROCESSING SYSTEM
- o WIND PRODUCTS
- o ICE PRODUCTS

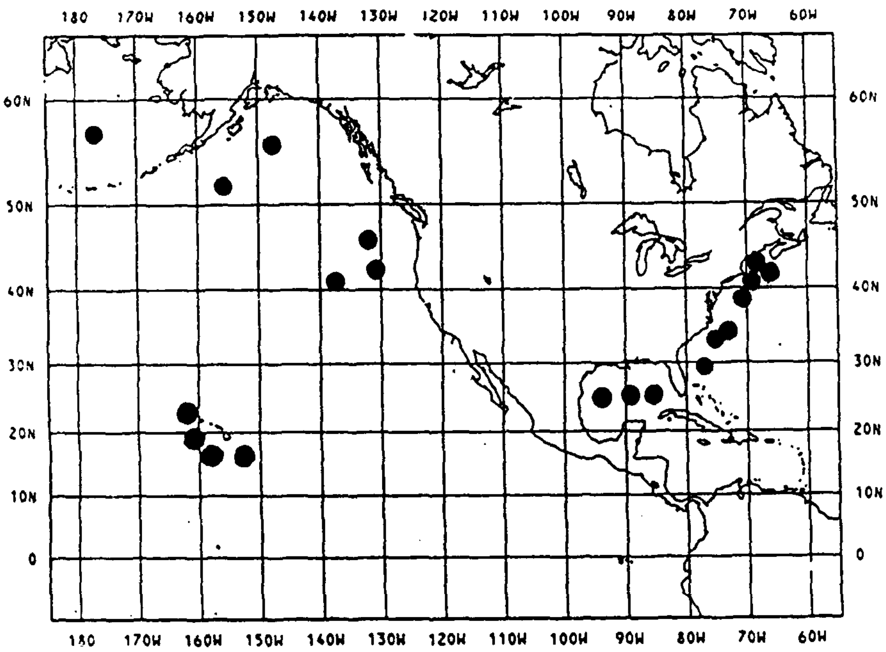
DATA FLOW: SSM/I EXPERIMENTAL PRODUCTS



SSM/I MARINE WIND SPEED ALGORITHM
(SSM/I CAL/VAL TEAM)

$$SW = 147.90 + 1.0969\,(T_{B19V}) - 0.4555\,(T_{B22V}) - 1.7600\,(T_{B37V}) + 0.7860\,(T_{B37H})$$

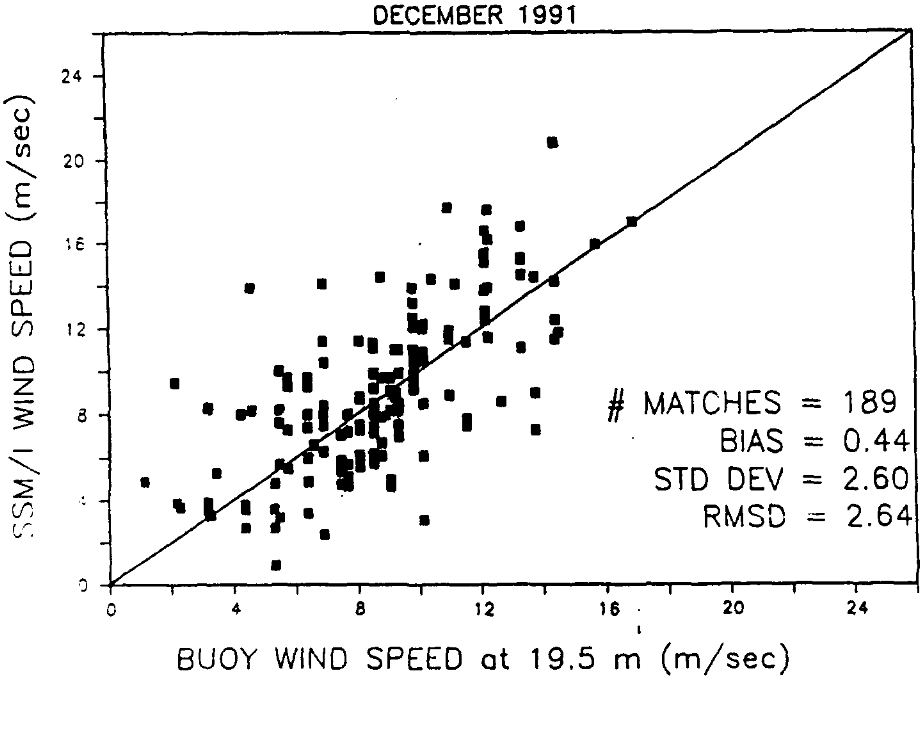
% OF DATA	RAIN FLAG	CRITERIA	ACCURACY
85%	0	$T_{B37V} - T_{B37H} > 50$ $T_{B19H} < 165$	< 2 m/s
15%	1	$T_{B37V} - T_{B37H} < 50$ $T_{B19H} > 165$	2 – 5 m/s
	2	$T_{B37V} - T_{B37H} < 37$	5 – 10 m/s
	3	$T_{B37V} - T_{B37H} < 30$	> 10 m/s



NOAA BUOYS USED TO MONITOR SSM/I WIND SPEED ACCURACY

SSM/I CAL/VAL WIND SPEED VS. BUOY

DECEMBER 1991



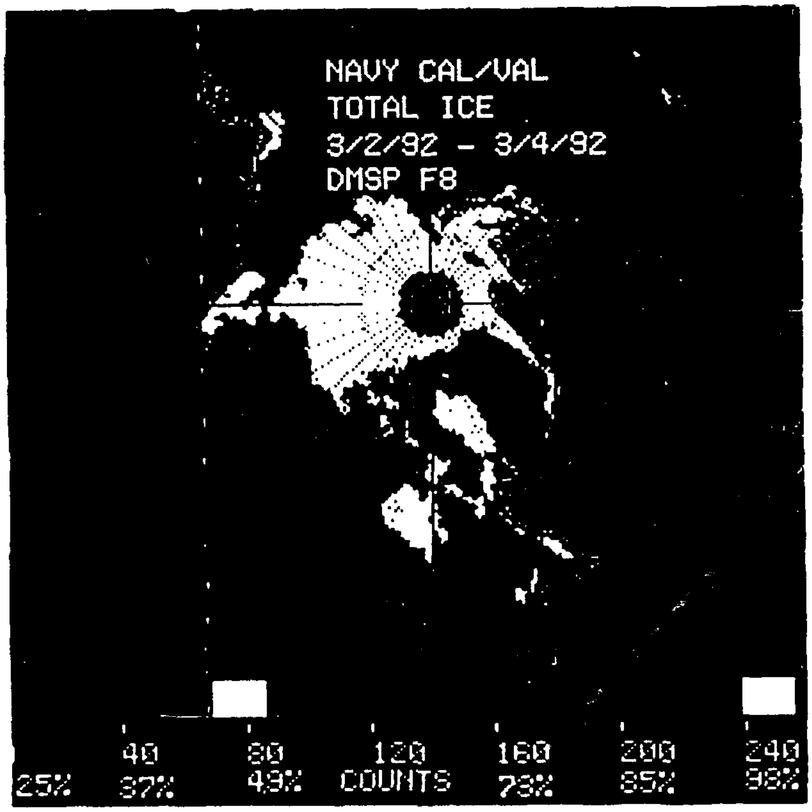
SSM/I -- BUOY WIND MATCH STATISTICS

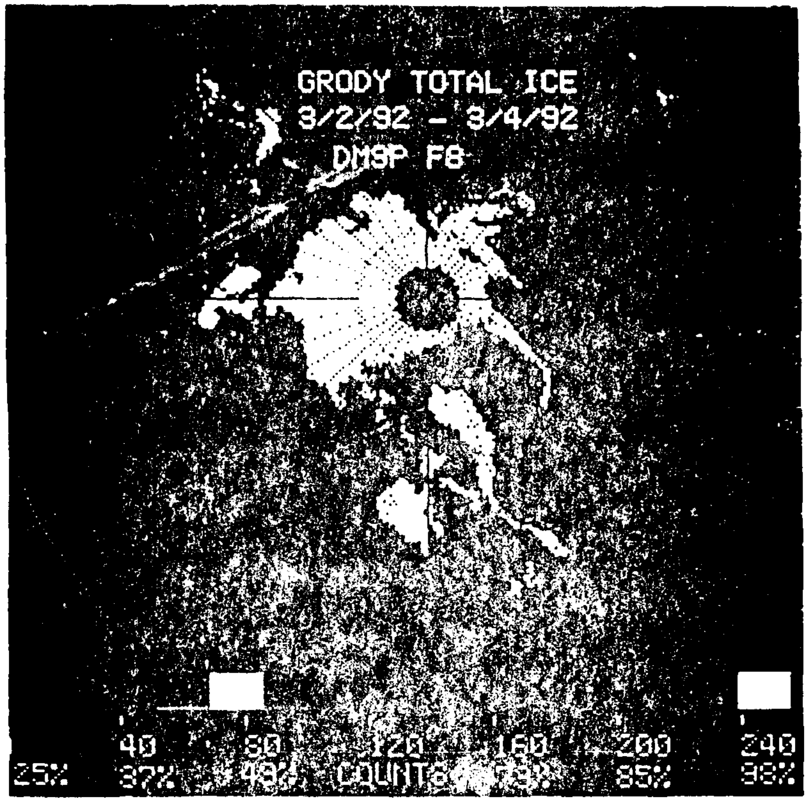
TIME PERIOD	# MATCHES	CAL/VAL R	CAL/VAL RMSD	TEST ALG. R	TEST ALG. RMSD
AUG 1991	258	0.68	2.04	-	-
NOV 13-30, 1991	168	0.65	2.34	0.68	2.37
DEC 1991	189	0.71	2.64	0.73	2.70
JAN 1992	104	0.79	2.33	0.82	2.30
FEB 1992	174	0.87	2.15	0.87	2.34
MAR 1992*	284	0.85	2.17	0.85	2.24

* March 1-5 (F-8) March 6-31 (F-10)

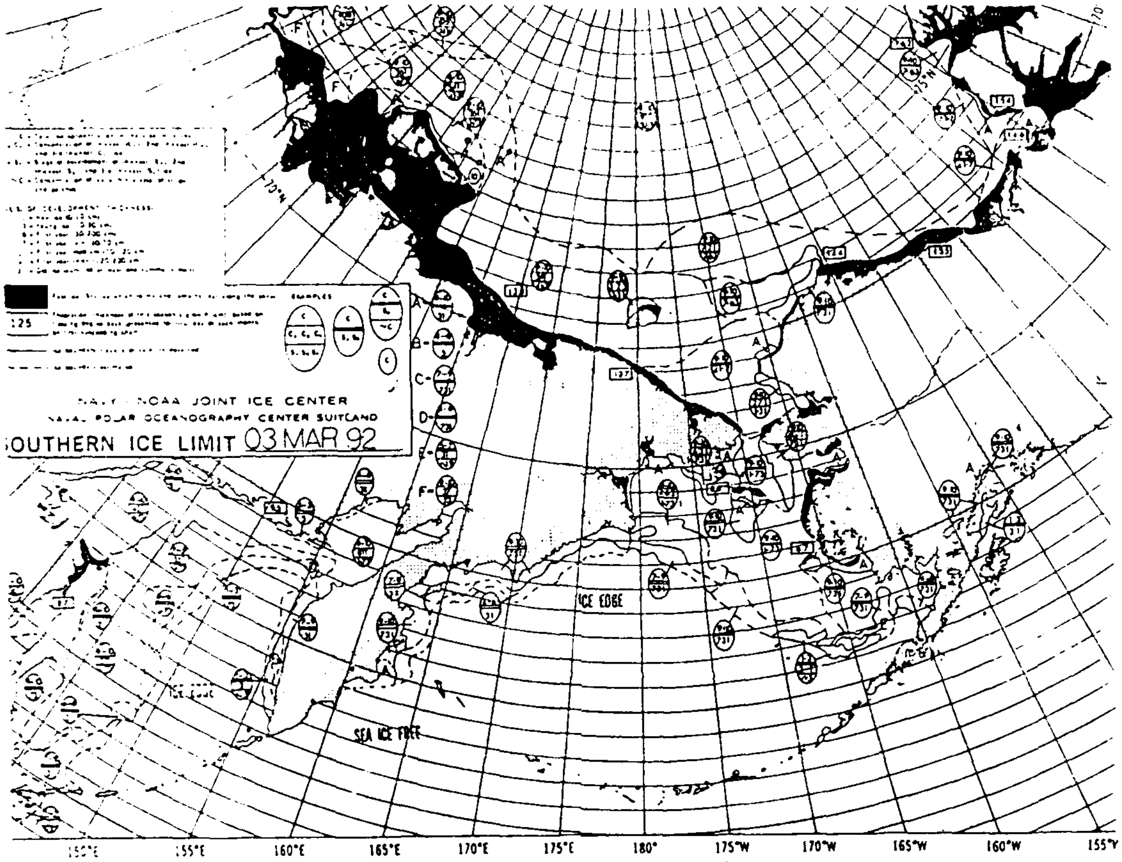
R = Correlation Coefficient

RMSD = Root Mean Square SSM/I - Buoy Difference




GRODY TOTAL ICE
3/2/92 - 3/4/92
DMSP F8
40 80 120 160 200 240
25% 37% 49% COUNTS 73% 85% 98%


NASA TOTAL ICE
3/2/92 - 3/4/92
DMSP F8
40 80 120 160 200 240
25% 37% 49% COUNTS 73% 85% 98%



SSM/I ICE AND WIND PRODUCTS

FUTURE PLANS

SYSTEM

- o TRANSITION TO OPERATIONS
- o SINGLE SYSTEM FOR ORBIT-BY-ORBIT AND MASTER MAPS
- o INCORPORATE FNOC PRODUCTS

WINDS

- o CONTINUE ALGORITHM ASSESSMENT (RAIN FLAGS)
- o WIND MATCH TWO SATELLITES
- o USE BUOY AND WIND QC FROM OPC
- o EVALUATE USE OF BUOY CONTINUOUS WINDS

ICE

- o CONTINUE ALGORITHM ASSESSMENT
- o IMPLEMENT LATEST NASA ALGORITHM UPGRADES
- o FORMAT ICE PRODUCTS FOR JIC DIFAS

REAL TIME QUALITY CONTROL OF SSM/I WIND SPEED DATA

Marshall Waters, W.S. Richardson, W.H. Gemmill and C.M. Caruso

NOAA Ocean Products Center
5200 Auth Road
Camp Springs, MD 20746

There is a critical need to increase the availability of accurate marine observations/ measurements. A new set of satellite derived (SSM/I) ocean surface wind speed data is now available in real time through the NOAA central computer facility. These measurements will allow NOAA to improve the accuracy of operational atmospheric and oceanographic forecast models and existing marine warning and forecast systems, and to study and quantify the long-term implications of climate and global change programs.

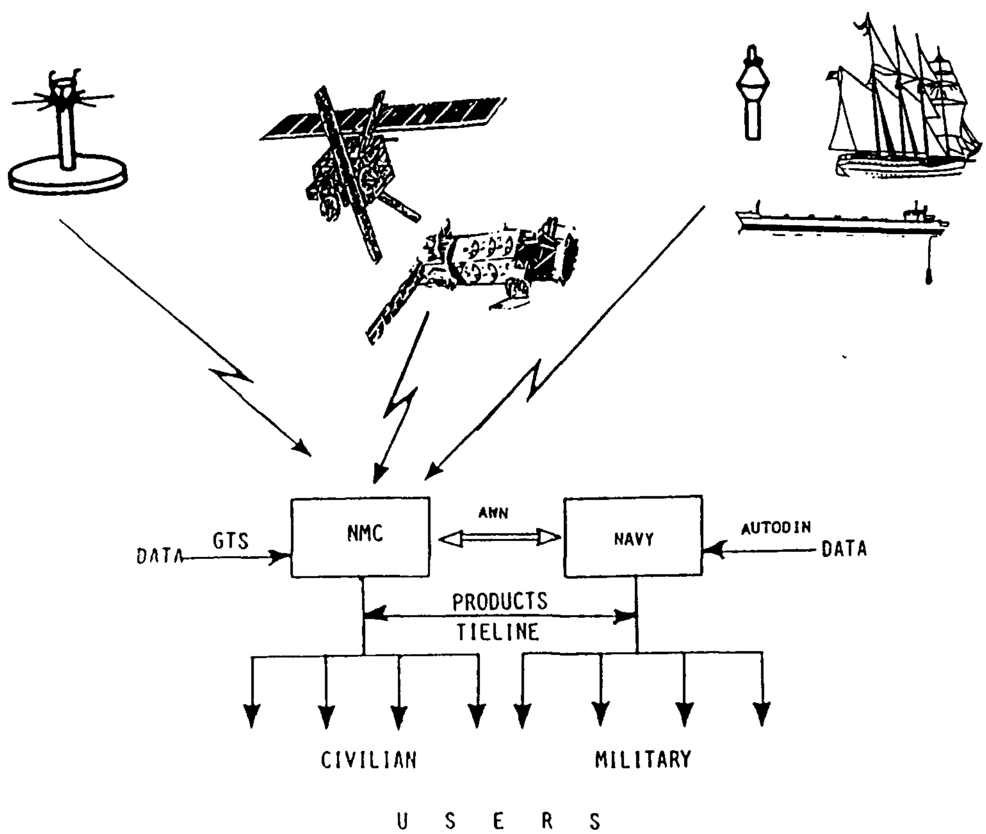
More accurate marine measurements are being made available by QUIPS (QUality Improvement Processing System). This system, which is operational at the NOAA Ocean Products Center, is described and discussed, as it relates to the quality control (QC) of SSM/I wind speeds. Discussion includes pre-processing and comparisons with an NMC first guess field, interactive QC on QUIPS and QC feedback for improved operational forecasts and SSM/I wind speed algorithm assessment/improvement.

REAL TIME QUALITY CONTROL

OF

SSM/I DERIVED WIND SPEED DATA

- o OVERVIEW
  - Data Flow
  - QC of In-Situ Data
- o QC OF SSM/I WIND DATA
  - "Super Obs"
  - Comparison to a First Guess
- o FUTURE PLANS
  - Interactive QC
  - Data Monitoring and QC Reports



SURFACE OBSERVATIONS/MEASUREMENTS QC'd

Four Synoptic Periods Each Day

Sea level pressure, wind speed, and
and air and sea surface temperatures

600 - Ships

350 - Buoys

90 - CMANs

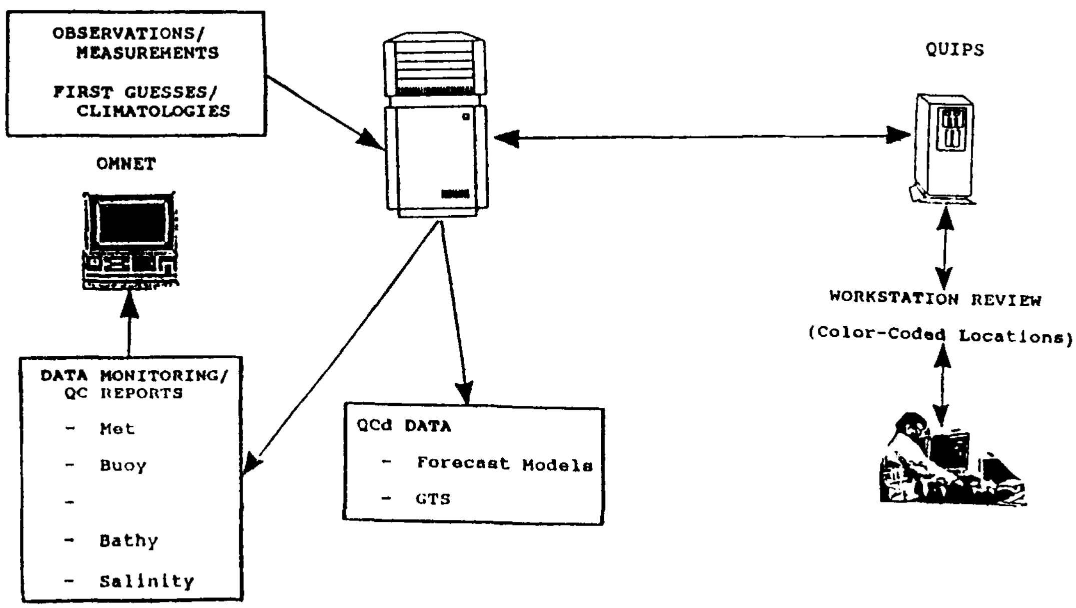
SUBSURFACE MEASUREMENTS QC'd

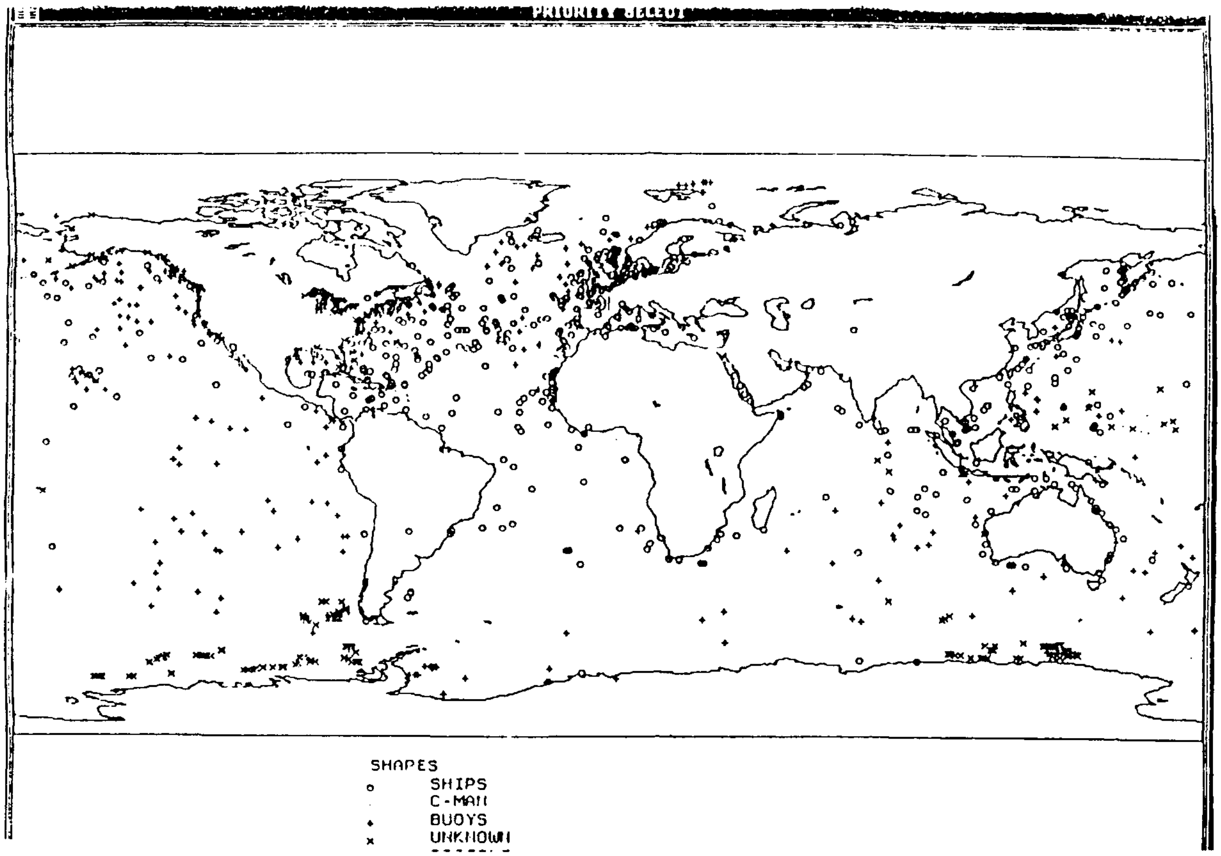
Once Each Day

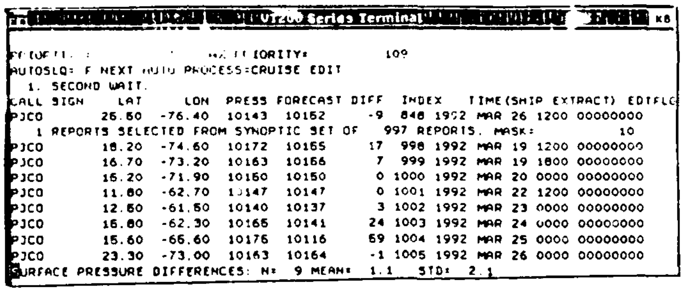
100 - Temperature Profiles

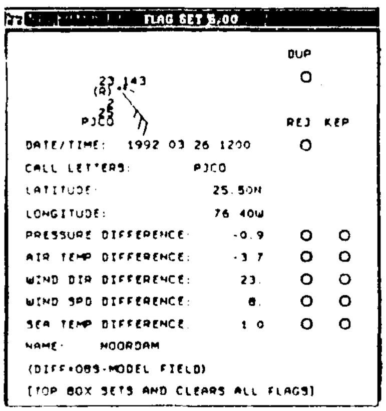
10 - Salinity Profifles

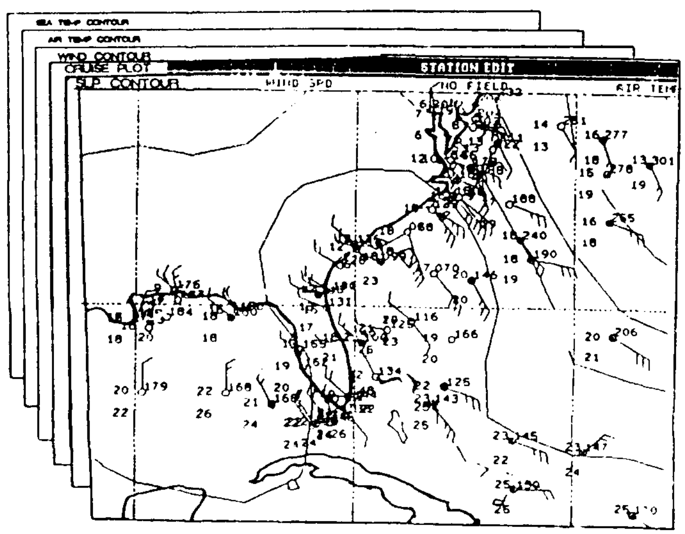
OPC REAL-TIME QUALITY CONTROL




PRIORITY SELECT
SHAPES
SHIPS
C-MAN
BUOYS
UNKNOWN


VT200 Series Terminal
PRIORITY= 109
AUTOSLQ= F NEXT AUTO PROCESS=CRUISE EDIT
1. SECOND WAIT.
CALL SIGN LAT LON PRESS FORECAST DIFF INDEX TIME(SHIP EXTRACT) EDTFLG
PJCO 25.50 -76.40 10143 10152 -9 848 1992 MAR 26 1200 00000000
1 REPORTS SELECTED FROM SYNOPTIC SET OF 997 REPORTS. MASK: 10
PJCO 18.20 -74.60 10172 10155 17 998 1992 MAR 19 1200 00000000
PJCO 16.70 -73.20 10163 10156 7 999 1992 MAR 19 1800 00000000
PJCO 16.20 -71.90 10150 10150 0 1000 1992 MAR 20 0000 00000000
PJCO 11.80 -62.70 10147 10147 0 1001 1992 MAR 22 1200 00000000
PJCO 12.60 -61.60 10140 10137 3 1002 1992 MAR 23 0000 00000000
PJCO 16.80 -62.30 10165 10141 24 1003 1992 MAR 24 0000 00000000
PJCO 15.60 -66.60 10176 10116 59 1004 1992 MAR 25 0000 00000000
PJCO 23.30 -73.00 10163 10164 -1 1005 1992 MAR 26 0000 00000000
SURFACE PRESSURE DIFFERENCES: N= 9 MEAN= 1.1 STD= 2.1


FLAG SET 5.00
DUP
PJCO
REJ KEP
DATE/TIME: 1992 03 26 1200
CALL LETTERS: PJCO
LATITUDE: 25.50N
LONGITUDE: 76 40W
PRESSURE DIFFERENCE: -0.9
AIR TEMP DIFFERENCE: -3.7
WIND DIR DIFFERENCE: 23.
WIND SPD DIFFERENCE: 8.
SEA TEMP DIFFERENCE: 1.0
NAME: NOORDAM
(DIFF=OBS-MODEL FIELD)
[TOP BOX SETS AND CLEARS ALL FLAGS]


SEA TEMP CONTOUR
AIR TEMP CONTOUR
WIND CONTOUR
CRUISE PLOT
SLP CONTOUR
STATION EDIT
WIND SPD
NO FIELD

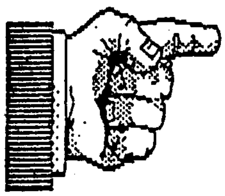
REAL TIME QUALITY CONTROL

OF

SSM/I DERIVED WIND SPEED DATA

o OVERVIEW

- Data Flow
- QC of In-Situ Data



o QC OF SSM/I WIND DATA

- "Super Obs"
- Comparison to a First Guess

o FUTURE PLANS

- Interactive QC
- Data Monitoring and QC Reports

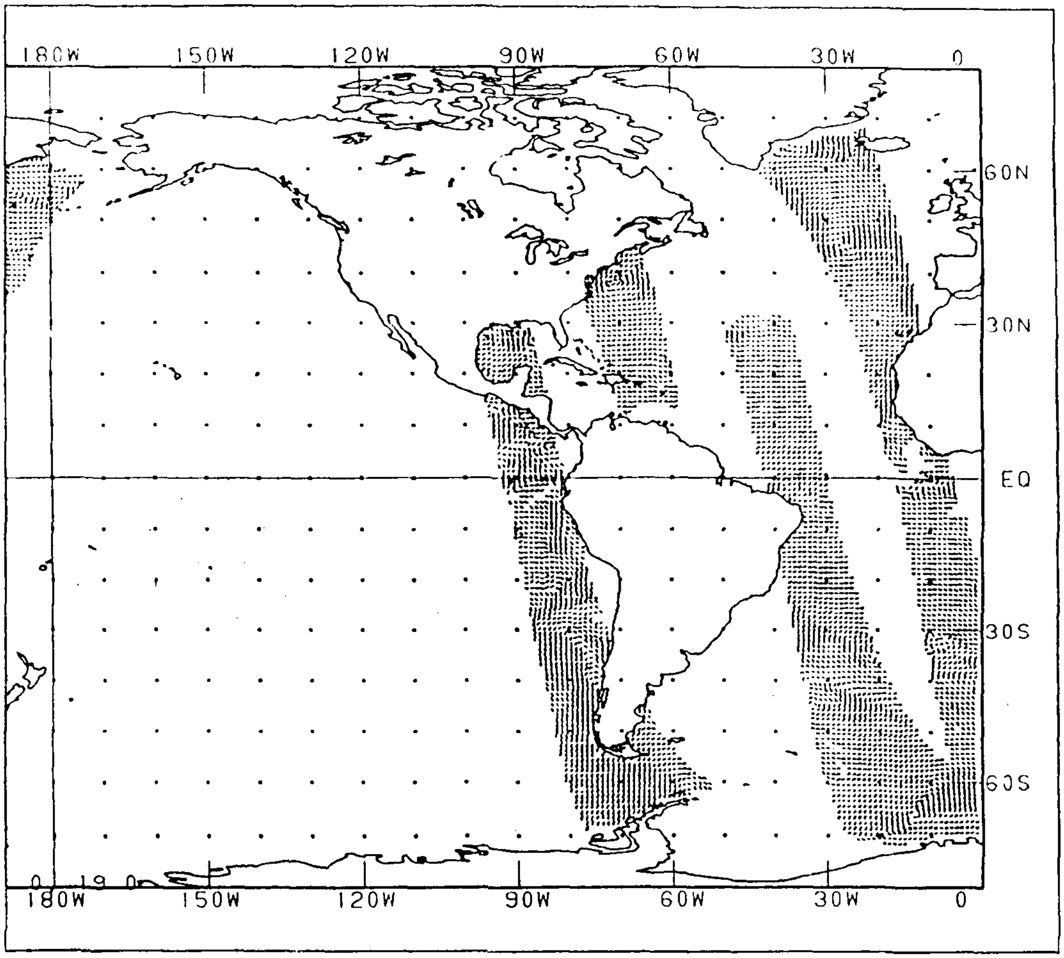
SSM/I "SUPER OBS"

o ALL "0" level (no precip contamination, no winds GE 25 m/s) measurements are placed in a 1 deg by 1 deg lat/long bin

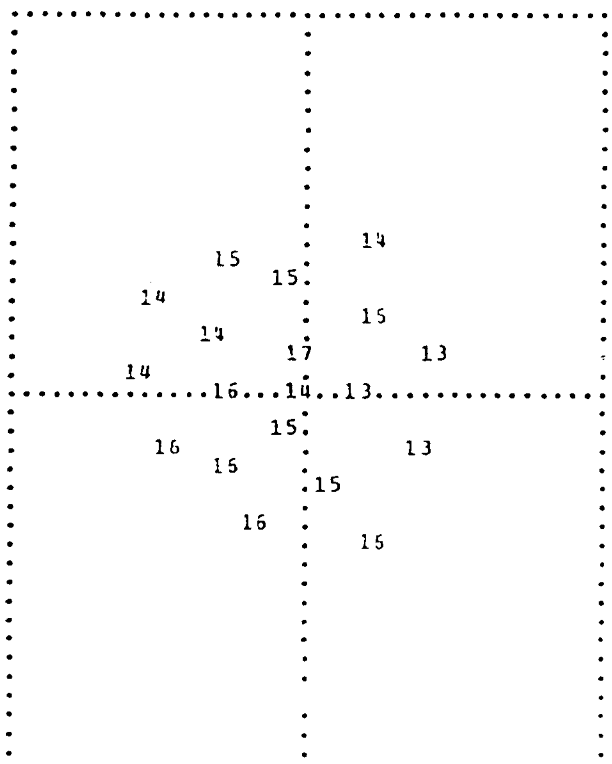
- Bins are determined by truncating lat/long to whole degrees
- The Super Ob is the linear average of all measurements in the 1 deg by 1 deg bin
- The location of the Super Ob is the linear average of lat/long's in the bin
- The time of the Super Ob is the linear average of the times of the Obs in the bin

o 5,000 - 6,000 "Super Obs" a Synoptic Period

o Data, within a 3 hr window, are collected 3 hrs into Synoptic Period



180W
150W
120W
90W
60W
30W
0
60N
30N
EQ
30S
60S

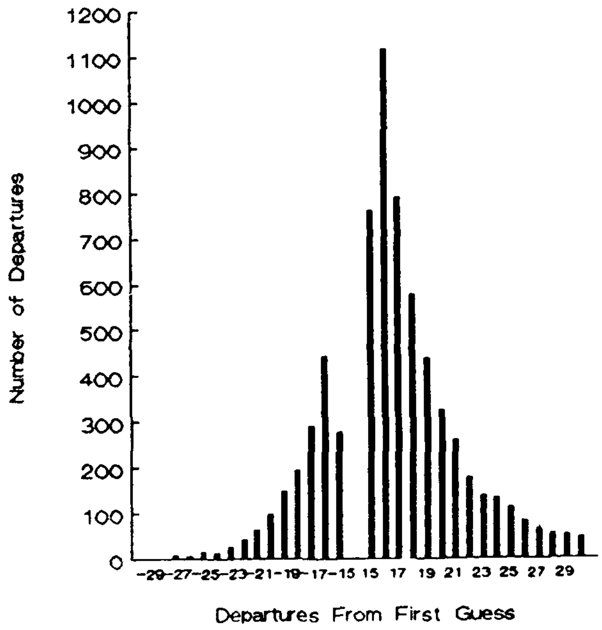


14
15
15
14
15
14
17
13
14
16
14
13
15
16
13
15
15
16
15

COMPARISONS TO A FIRST GUESS

- o First Guess
  - 06 Hr Forecast of Wind Speed 45 m above the Sfc
  - Global Data Assimilation (GDAS) run at 06Z and 18Z
    -- Verifies at 12Z and 00Z --
  - Aviation (AVN) run at 00Z and 12Z
    -- Verifies at 06Z and 18Z --
- o Approximately 1.5 % (75 Super Obs) of the nearly 5,000 Super Obs per Synoptic Period, DEPART by +/- 15 kts or more from the First Guess

Comparison of SSM/I Derived Winds
To NMC First Guess
November 5-19, 1991



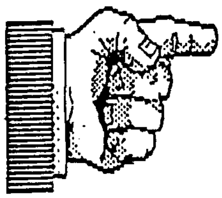
ABS (SSM/I - First Guess) >= 15 Kts.
(Approximately 1.5% of data)

REAL TIME QUALITY CONTROL

OF

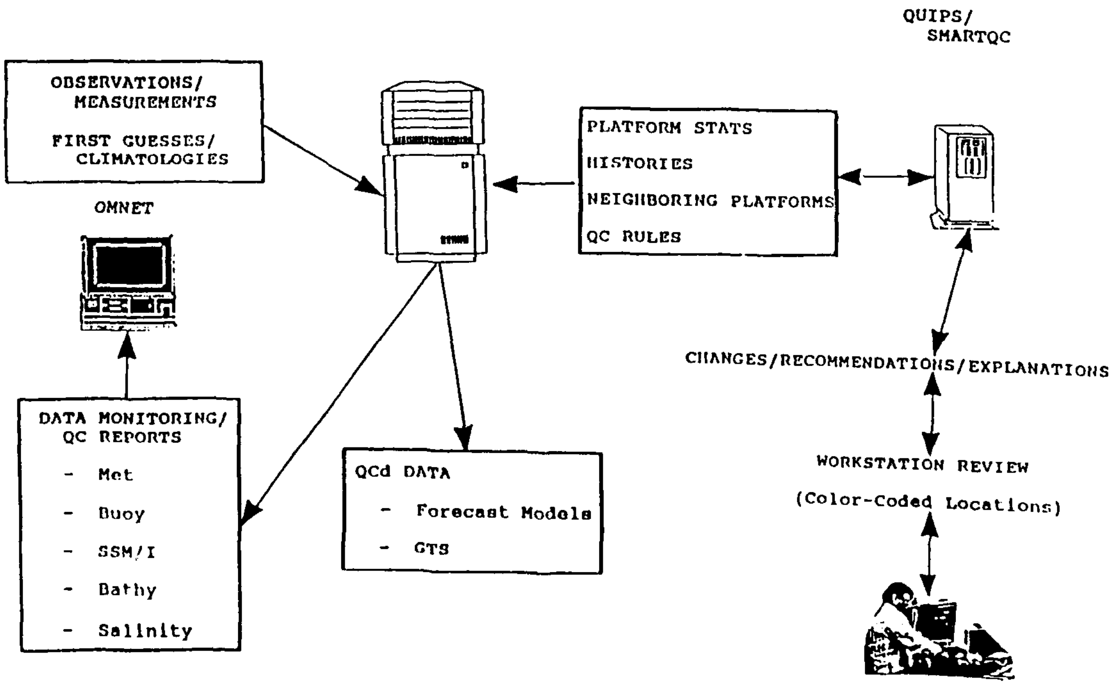
SSM/I DERIVED WIND SPEED DATA

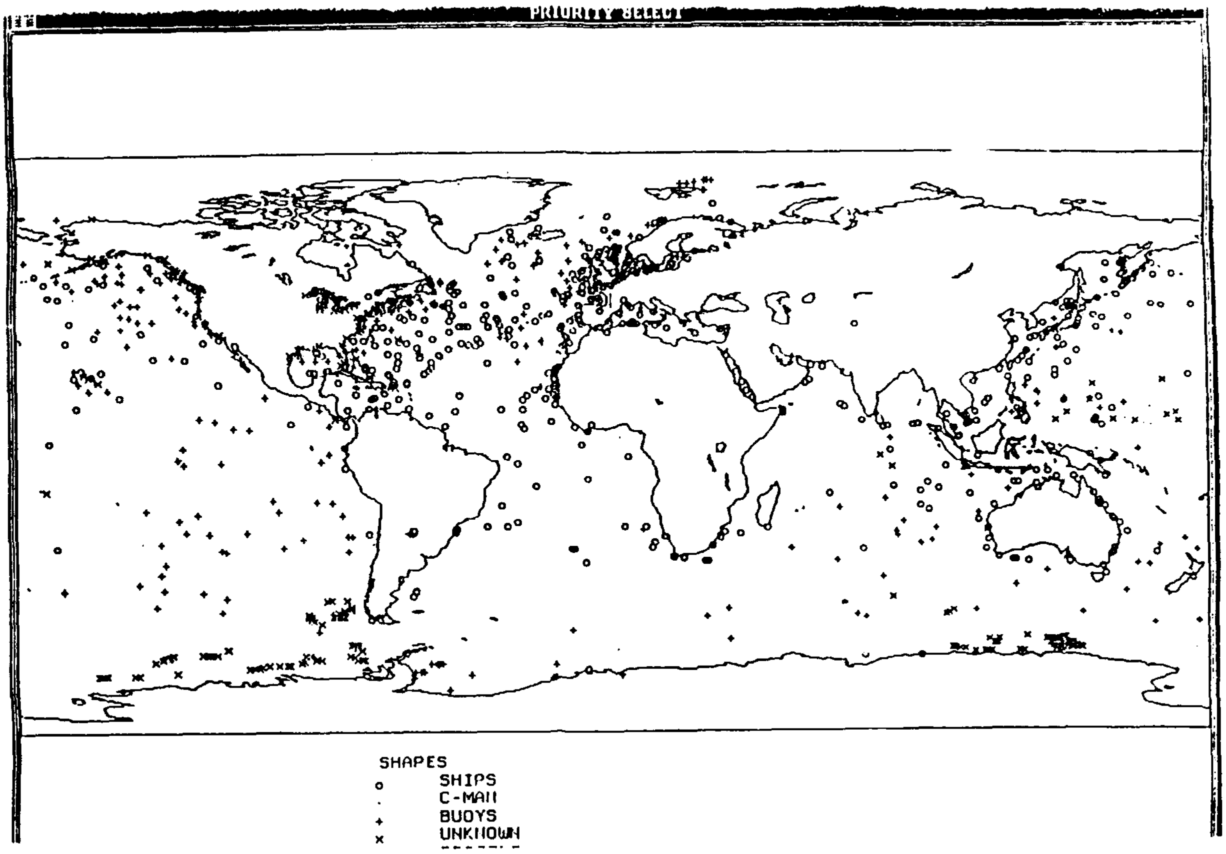
- o OVERVIEW
  - Data Flow
  - QC of In-Situ Data
- o QC OF SSM/I WIND DATA
  - "Super Obs"
  - Comparison to a First Guess

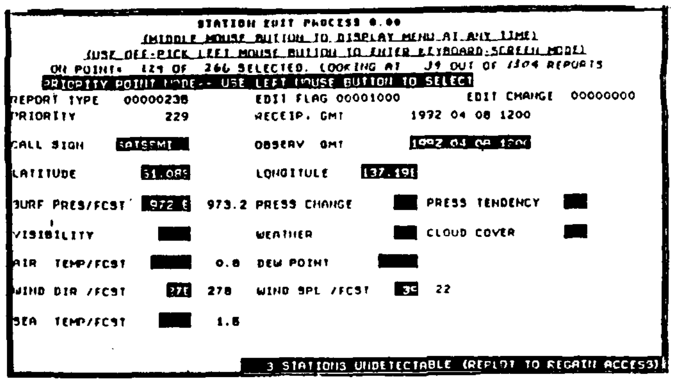


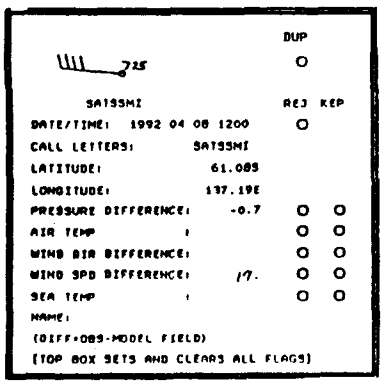
- o FUTURE PLANS
  - Interactive QC
  - Data Monitoring and QC Reports

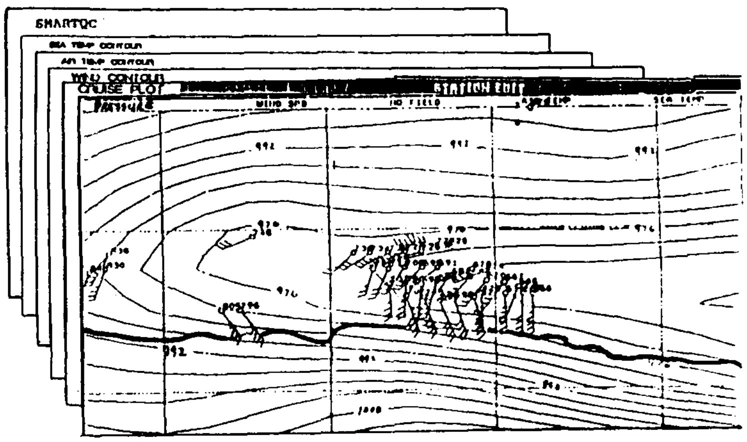
OPC REAL-TIME QUALITY CONTROL




PRIORITY SELECT
SHAPES
SHIPS
C-MAN
BUOYS
UNKNOWN


STATION EDIT PROCESS
(MIDDLE MOUSE BUTTON TO DISPLAY MENU AT ANY TIME)
PRIORITY POINT MODE-- USE LEFT MOUSE BUTTON TO SELECT
REPORT TYPE 00000238
EDIT FLAG 00001000
EDIT CHANGE 00000000
PRIORITY 229
RECEIP. GMT 1992 04 08 1200
CALL SIGN
OBSERV GMT
LATITUDE
LONGITUDE
SURF PRES/FCST 973.2
PRESS CHANGE
PRESS TENDENCY
VISIBILITY
WEATHER
CLOUD COVER
AIR TEMP/FCST 0.8
DEW POINT
WIND DIR /FCST 278
WIND SPD /FCST 22
SEA TEMP/FCST 1.6
3 STATIONS UNDETECTABLE (REPLOT TO REGAIN ACCESS)


DUP
SATSSMI
REJ KEP
DATE/TIME: 1992 04 08 1200
CALL LETTERS: SATSSMI
LATITUDE: 61.08S
LONGITUDE: 137.19E
PRESSURE DIFFERENCE: -0.7
AIR TEMP
WIND DIR DIFFERENCE:
WIND SPD DIFFERENCE:
SEA TEMP
NAME:
(DIFF=OBS-MODEL FIELD)
(TOP BOX SETS AND CLEARS ALL FLAGS)


SHARTQC
SEA TEMP CONTOUR
AIR TEMP CONTOUR
WIND CONTOUR
CRUISE PLOT
PRESSURE
STATION EDIT

SMARTQC WINDOW

SMARTQC RECOMMENDATION(S)

PLAT TYPE	ID	LAT	LONG	COURSE	MON	DAY/TIME
SSMI	SATSSMI	61.08S	137.19E		APR	08/1200

D/S LOCATION

HIST LOCATION

	OB	FGS	DIF	BIAS	STD	#	CORR	TRNS	BCF	#	FC
WND	39.0	22.0	17.0						95%	3	95%

SSMI WINDS ARE IN AGREEMENT WITH ALTIMETER AND SCATTEROMETER WINDS

ACCEPT SSMI WINDS

FEEDBACK TO ALGORITHM DEVELOPERS AND MODELERS

Monthly Summary of Departures

- By Regions (latitudinal bounds)
- Purged by QUIPS Operator
- Extreme Departures (GE to +/-30 kts)
- By Precip Areas

SSM/I DERIVED WIND SPEED DEPARTURES

FROM FIRST GUESS BY LATITUDINAL REGIONS

November 5 - 19, 1991

REGION	NUMBER OF DEPARTURES (15 KTS)	PERCENT NEGATIVE
GE 50 N	1,085	9.9
31 N - 50 N	1,708	37.3
11 N - 30 N	381	1.6
0 N - 10 N	388	0.0
0 S - 10 S	353	0.0
11 S - 30 S	305	0.7
31 S - 50 S	1,623	45.7
GE 50 S	1,043	10.5
TOTAL	6,886	23.6

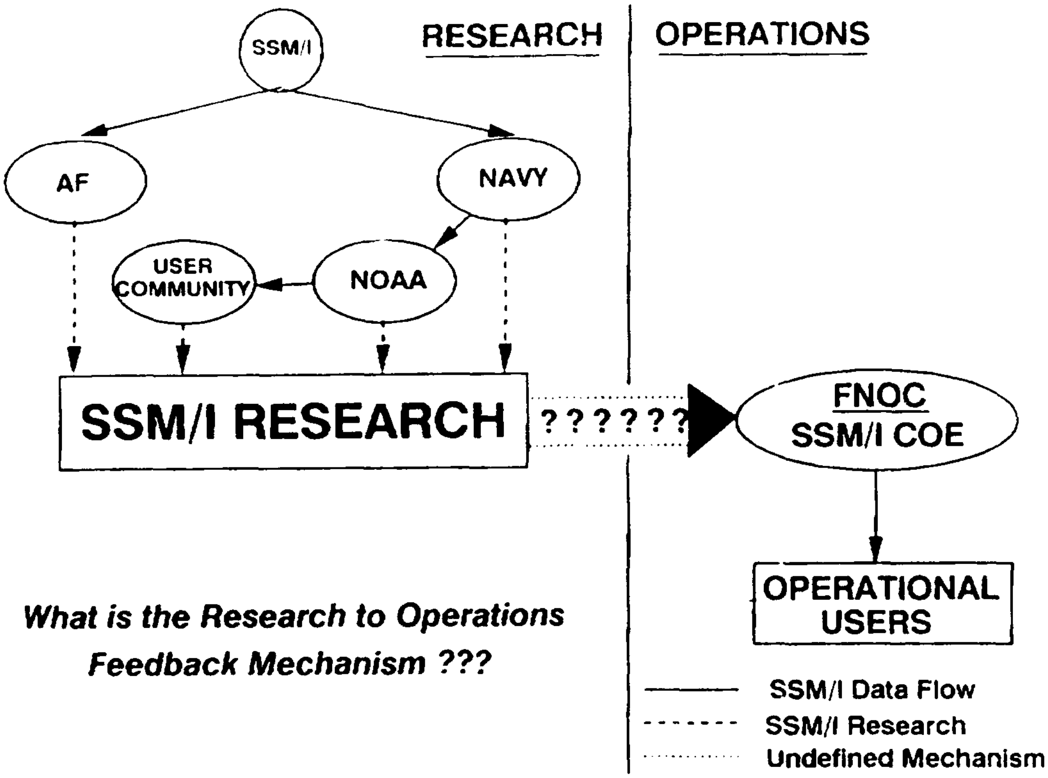
THE 6,886 WIND SPEED DEPARTURES REPRESENTS ONLY 1.5% OF THE MORE THAN HALF MILLION SSM/I SUPER OBS

STATUS OF NESDIS DISTRIBUTION OF SSM/I PRODUCTS

P. Taylor

NOAA/NESDIS
Washington, DC 20233

In late 1991, limited testing began for transmission of SSM/I products from Fleet Numerical Oceanographic Center (FNOC) in Monterey, CA to NOAA/NESDIS in Suitland, MD via the Shared Processing Network (SPN). These products generated at the SSM/I Shared Processing Center of Expertise (COE) - FNOC - include Antenna Temperatures (TDRs), Brightness Temperatures (SDRs), and Derived Environmental Products (EDRs). By mid-summer 1992 NOAA/NESDIS plans to 1) have the processing system to unpack and decode these products in place, 2) have these transmissions validated, and 3) increase the frequency of transmissions to include all SSM/I data orbits from two operational DMSP spacecraft. Throughout the past year experimental generation by NESDIS of some of the SSM/I EDR's has enabled NOAA users to analyze these products prior to their routine availability from FNOC. Parallel testing of the products has demonstrated their utility for weather and climate applications and has resulted in formal requests from the National Meteorological Center, and National Hurricane Center, and the NAVY/NOAA Joint Ice Center for operational access to SSM/I products. In order to respond to these requests a system to format the FNOC products for NOAA users, provide science support to the Navy for product enhancement, and distribute the products is required. This presentation will review the preliminary design for the proposed NESDIS SSM/I Operational System for distribution, science support, and archive of the FNOC products.



What is the Research to Operations Feedback Mechanism ???

PROCESSING AND DISTRIBUTING SSM/I DATA VIA THE WETNET PROJECT

H. Michael Goodman

Earth Science and Applications Division
NASA/Marshall Space Flight Center
Huntsville, Alabama

WetNet is a NASA sponsored research project designed to promote inter-disciplinary research in the atmospheric, related oceanic, hydrologic and land surface sciences. The project currently provides SSM/I data and derived data products to over forty U.S. and international scientists. The project is more than a data service. The intent is to provide common data sets, analysis software, and image display workstation to a diverse groups of researchers in order to facilitate cooperative research across the Earth sciences. The current project status and future developments will be presented. The emphasis will be on data processed to date, problems encountered and solutions devised, data distribution media, services provided, and the future direction of the project.

The WetNet Program

Marshall Space Flight Center
March 1992

WetNet

WetNet is an interdisciplinary, interactive data analysis and research project devoted to the study of the global hydrologic cycle

Wet: *studies of the global hydrologic cycle*

Net: *develop and test a remote interactive computer network in an Earth system science research environment*

Marshall Space Flight Center
March 1992

Science Objective

To promote Earth system science research through cooperative studies of the global hydrologic cycle.

The Special Sensor Microwave / Imager (SSM/I) instrument data sets are provided as a common data set from which interdisciplinary working groups can conduct passive microwave investigations.

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Network Objective

To utilize existing computer communication networks and optical disk technology to distribute data sets to a diverse group of Earth system science researchers.

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March 1992

Earth Observing System

- EOS Observatories - coordinated international suite of instruments and platforms for long term remote sensing.
- EOS Scientific Research Program - sustained Earth science research commitment for the purpose of data analysis and integration into predictive models.
- EOS Data and Information System (EOSDIS) - science driven data system with an open and distributed architecture. Learn and evolve from existing data systems and prototypes.

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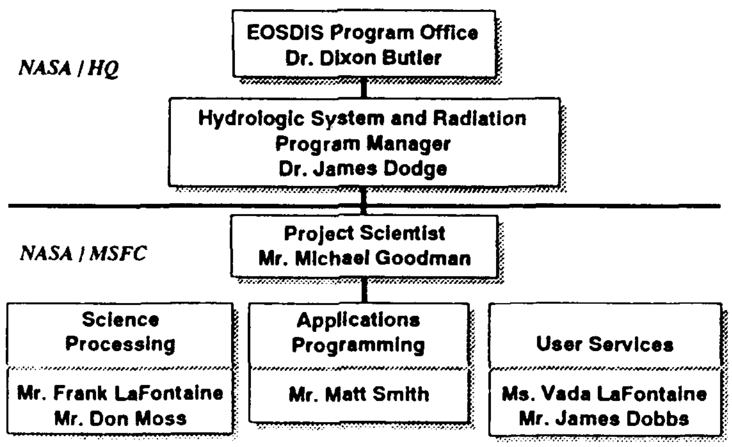
March 1992

WetNet Organizational Chart

NASA Earth Science and Applications Division



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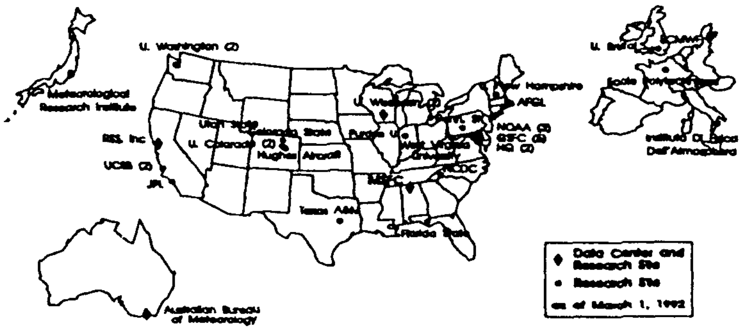
March 1992

WetNet Research and Data Locations



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March 1992

WetNet Scientists

Bob Adler	NASA/Goddard Space Flight Center
John C. Alishouse	NOAA/NESDIS
Richard L. Armstrong	National Snow and Ice Data Center
Susan Avery	University of Colorado
Eric Barrett	University of Bristol
Francis Bretherton	University of Wisconsin-Madison
Robert A. Brown	University of Washington
Donald J. Cavalieri	NASA/Goddard Space Flight Center
Alfred T. Chang	NASA/Goddard Space Flight Center
Alaine Chedin	Ecole Polytechnique
Bhaskar J. Choudhury	NASA/Goddard Space Flight Center
Robert G. Crane	The Pennsylvania State University
James Dodge	NASA Headquarters
Robert N. Ell	West Virginia University

Marshall Space Flight Center
March 1992

WetNet Scientists

William Emery	University of Colorado
Gerry W. Felde	U. S. Air Force Geophysics Laboratory
Kevin P. Gallo	National Climatic Data Center
Catherine Gautier	University of California-Santa Barbara
Steven Goodman	NASA/Marshall Space Flight Center
Kenneth Hardy	Lockheed Missle & Space Co. Inc.
Jim Hollinger	Naval Research Laboratory
Tony Hollingsworth	European Centre for Medium-Range Weather Forecasts
Greg Hunolt	NASA Headquarters
Nicole Husson	Ecole Polytechnique
John E. Janowiak	NOAA/NWS/NMC - Climate Analysis Center
John F. LeMarshall	Australian Bureau of Meteorology
Timothy Liu	NASA/Jet Propulsion Laboratory
James P. McGuirk	Texas A&M University

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March 1992

WetNet Scientists

Alberto Mugnai	Instituto Di Fisica Dell'Atmosfera/CNR
Christopher Neale	Utah State University
William S. Olson	University of Wisconsin-Madison
Grant Petty	Purdue University
Franklin R. Robertson	NASA/Marshall Space Flight Center
Barry Rock	University of New Hampshire
Richard C. Savage	Hughes Aircraft Co.
Akira Shibata	Meteorological Research Institute
Eric A. Smith	Florida State University
Roy Spencer	NASA/Marshall Space Flight Center
Jeff Star	University of California-Santa Barbara
Graeme L. Stephens	Colorado State University
Fran Stetina	NASA/Goddard Space Flight Center
Frank J. Wentz	Remote Sensing Systems

Marshall Space Flight Center
March 1992

Examples of Research

NASA

Savage & Heinrichs (Hughes Aircraft) - vegetation classification using SSM/I and comparisons with OLS derived vegetation classification. Stress identification to distinguish healthy from stressed vegetation.

Phalipou (ECMWF) - Comparisons of global precipitable water with ECMWF model predictions. Comparisons of radiosonde moisture calculations with SSM/I total precipitable water.

Smith, et. al. (Florida State U.) - Spatial resolution ehancement of 19 & 37 GHz SSM/I brightness temperatures through deconvolution procedures.

Barrett, et. al. (U. of Bristol, U.K.)- Global precipitation intercomparison project (PIP-1). Demonstrate, test, intercompare, and validate techniques for global monthly rainfall monitoring by SSM/I . Determine which techniques function best over land, ocean, ice and snow covered surfaces.

Zipser & McGuirk (Texas A&M U.) - Determination of SSM/I usefulness in categorizing, measuring, and parameterizing the effects of global rainfall with emphasis on the effect of mesoscale convective systems.

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Data Sources

NASA

- Utilize space-based measurements from:
  - SSM/I (F8, F10 & F11)
  - Geo Satellites (GOES, Meteosat, GMS)
- Utilize ground-based measurements from:
  - Radar (USA coverage) (future)
  - Surface observations (future)
  - Rawinsonde observations (future)

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Satellite & Instrument Characteristics

- Passive microwave radiometric system
- Four bi-polarized frequencies
  - V85, V37, V22, V19
  - H85, H37, H19
- Spatial Resolution

85 GHz:	15 x 13 km
37 GHz:	38 x 30 km
22 GHz:	60 x 40 km
19 GHz:	70 x 45 km

● Swath Width:	1394 km
● Altitude:	833 km
● Scan spacing:	12.5 km (1.90 s)
● Orbits / day:	14.2

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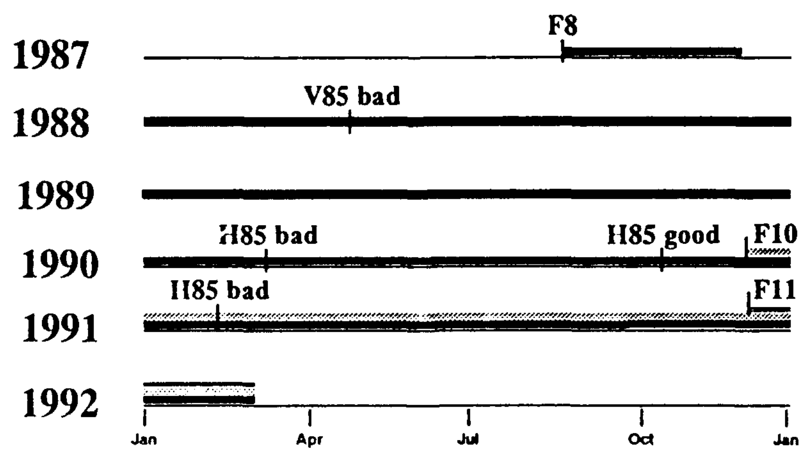
SSM/I Data Availability



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Data Set Composition
SSM/I and Geostationary

- SSM/I Daily Browse (Ascending & Descending)

  V85, H85, V37, H37, V22, V19, H19

- SSM/I Full Resolution Swaths (Ascending & Descending)

  V85, H85, V37, H37, V22, V19, H19

- SSM/I Full Resolution Swath Catalog
- GOES Infrared

  GOES East at 00Z and 12Z,

  GOES West at 02Z and 14Z

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Data Set Composition
SSM/I Products

- **SSM/I Products Daily Browse**

  Rain Rate (Olson, et. al.)
  Total Precipitable Water (Allshouse, et. al.)
  Cloud Liquid Water (Allshouse, et. al.)
  Marine Wind Speed (Goodberlet, et. al.)
  Land Classification (Neale, et. al.)
  Land Surface Temperature (McFarland, et. al.)

- **SSM/I Products Cartridge Composite**

  Rain Rate (Olson, et. al.)
  Total Precipitable Water (Allshouse, et. al.)
  Cloud Liquid Water (Allshouse, et. al.)
  Marine Wind Speed (Goodberlet, et. al.)
  Land Classification (Neale, et. al.)
  Land Surface Temperature (McFarland, et. al.)
  Precipitaton Identifier (Spencer)
  Snow Water Equivalent (Chang)
  Vegetation Index (v37 - h37)
  Sea Ice Fraction (Ramseier, et al.)
  Sea Ice Age (Ramseier, et al.)

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NASA

Data Set Composition
Applications and Ancillary Software

- **Software**
  - McIDAS- OS2
  - WetNet Software
  - User Contributed Software
- **Documentation**
  - Help Files
  - System Documentation
- **Demonstrations**
  - Tutorials

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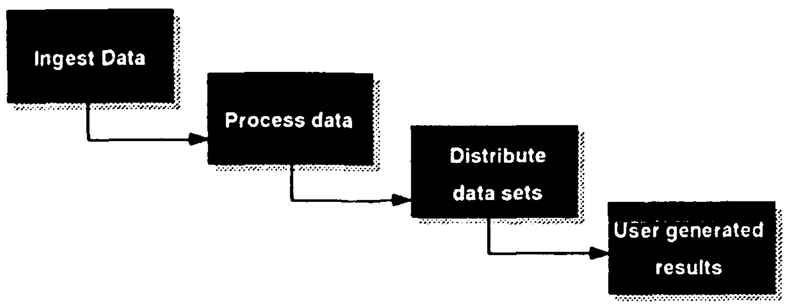
March 1992

NASA

WetNet Data Flow Chart



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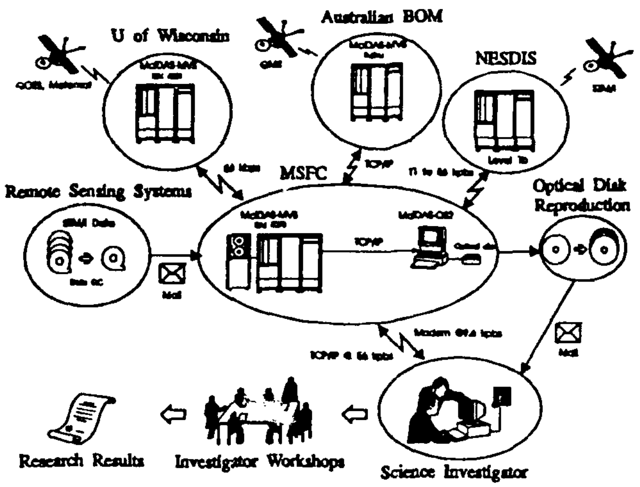
WetNet Data Acquisition and Distribution



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Data Management & Distribution

- Develop browse and catalog algorithms for managing large image based datasets.
- Explore the use of optical disks as a reliable storage media and as a "high bandwidth" data transfer mechanism.
- Use existing computer networks (where feasible) to distribute daily browse datasets.

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WetNet Schedule

NASA

Date	Activity
Apr 21-24	WetNet science meeting at Florida State University
May	Internet data distribution
Fall	WetNet Training session
Fall	SSM/I from additional satellite
Spring 93	1993 WetNet science meeting at ?

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March 1992

NASA

Hardware and Software Specifications

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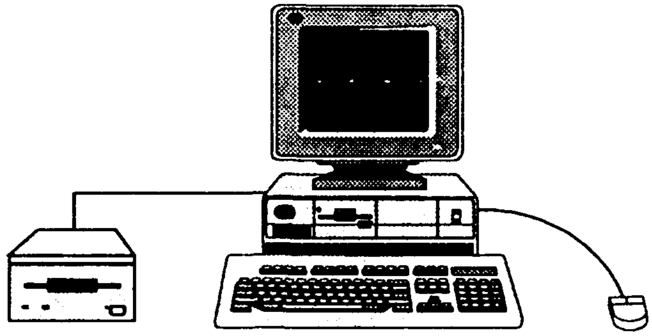
March 1992

WetNet Workstation Configuration



Sony Magneto-Optical
650 MBytes

IBM PS/2 Model 70-A16
160 MByte Hard Disk
6 MBytes RAM
3Com or Western Digital
Ethernet card

Mouse

Marshall Space Flight Center
March 1992

WetNet Hardware

- System Unit
  - IBM PS/ 2 Model 70 - A16
  - Intel 80386 Processor/80387 Math Co-Processor
  - 6 MBytes RAM
  - 160 MByte Hard Disk
  - three slots (two 16-bit, one 8-bit)
  - Mouse
- Monitor
  - VGA
- Magneto-Optical Drive
  - Sony Rewritable / Erasable
  - Adaptec SCSI Adapter
- Ethernet Adapter
  - 3COM or Western Digital

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March 1992

System Software

- Operating System
  - IBM Operating System/2
    Standard Edition (SE) v1.3 or v2.0
- McIDAS
  - McIDAS-OS2 v5.5
- TCP/IP
  - IBM TCP/IP for OS/2 v1.2

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McIDAS-OS2 Programming

What you need

- Microsoft FORTRAN 5.1
- Applications Programming Manual
- Knowledge of FORTRAN
- McIDAS-OS2 source code

Document and share your code

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March 1992

Session 3: New Retrieval Approaches and Products and Relevance to AMSU (Ohring, chair)

In this session, research results were presented on the development of an advanced satellite retrieval system, new retrieval approaches, and the use of DMSP SSM/T and SSM/I data to develop retrieval methodologies for NOAA's Advanced Microwave Sounding Unit-A (AMSU-A). AMSU-A, which is scheduled for launch on the NOAA-K satellite in 1995, is a 15-channel temperature sounder with many channels similar to those on SSM/T and SSM/I.

W. Baker of NOAA/NMC discussed a joint NESDIS/NASA/NMC research program to develop an advanced satellite retrieval system that is an integral part of NMC's numerical weather analysis and prediction model. The new system incorporates the best components of the operational retrieval system at NESDIS and the experimental approach at NASA. A key aspect of the new system is the use of the 6-hour forecast temperature profiles as first guesses in the satellite retrieval process. Test results are encouraging and the system is scheduled for operational implementation during 1992.

L. McMillin of the NOAA Satellite Research Laboratory reported on his work in the use of a classification approach to provide an initial temperature profile for the retrieval process. Application of the method to TOVS data suggests an increase in accuracy of 0.2-0.3°C compared to the use of a library search first guess. Similar results are obtained when the method is applied to the microwave-only observations of the SSM/T.

In a companion pair of papers, H. Fleming of the NOAA Satellite Research Laboratory and E. Kratz of SM Systems and Research Corporation discussed the derivation and application of a physical retrieval algorithm for SSM/T. The method is a two-part retrieval procedure; the first part produces an atmospheric temperature profile and the second part produces surface (skin) temperature and surface emissivity at 50 GHz. Comparisons of retrieved temperatures with coincident radiosonde temperature profiles indicate that the accuracy of this physical approach is comparable to the operational, regression based, retrieval algorithm, but produces the two surface parameters which the regression approach cannot do.

J.I.F. King of the USAF Phillips Laboratory described the application of the zeta-function transform to the satellite temperature retrieval problem. In conventional approaches, the radiance integral is expressed as a finite sum quadrature with the matrix then inverted to yield the temperature. In the proposed approach, a moment method is used to approximate the temperature profiles at three interacting bilateral wave packets. Application of the zeta-function transform to the three packets reduces the complex interaction of the radiance and temperature profiles to a simple subtractive operation. Examples illustrated the quantitative relationship between radiance observation noise and the retrieval accuracy.

P.W. Rosenkranz of M.I.T. discussed SSM/I measurements as predictors of the response of AMSU-A to surface and atmospheric phenomena. SSM/I's channels (19, 22, 37, and 85 GHz) are similar to the AMSU-A window channels (24, 31, 50, and 89 GHz). Differences in incidence angle and polarization between the two instruments are reconciled by reasonable assumptions about angle and polarization dependence. The SSM/I data show signatures of rough seas, sea ice, snow cover, and precipitation that are relevant to the interpretation of the measurements to be made by AMSU-A.

SESSION 3 - NEW RETRIEVAL APPROACHES AND PRODUCTS; RELEVANCE TO AMSU

JOINT NESDIS/NASA/NMC EFFORT TO DEVELOP AN ADVANCED SATELLITE RETRIEVAL SYSTEM

Wayman Baker

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1. Introduction

The accuracy of operational numerical weather forecasts has steadily increased during the past decade to the point where it is becoming difficult to routinely expect operational satellite temperature soundings to have a positive impact on the forecasts over the Northern Hemisphere. The realization of the importance of the satellite retrieval problem to numerical weather prediction (NWP) culminated in the convening of a U.S. government Interagency Satellite Retrieval Workshop in July 1989 at NMC which included satellite retrieval and NWP experts from NASA and NOAA. The Workshop participants agreed that an advanced satellite retrieval system for numerical weather forecasting and climate monitoring should be developed as soon as possible. This system should take advantage of the best components of the operational system at NESDIS and those from the experimental approaches at NESDIS and at NASA. There was a strong consensus among the Workshop participants, that, over most of the globe, the present-day accuracy of the model 6-hour forecast during the data assimilation should be beneficial to the retrieval process. The approach of producing and using the satellite soundings "interactively" then naturally follows, where the assimilation model forecast is used as a first guess by the retrieval scheme (Baker et al., 1984). The resulting retrievals are then analyzed in conjunction with other available data to produce initial conditions for the subsequent forecast by the assimilating model. Such an approach, developed and used extensively in a research mode by J. Susskind and collaborators at the NASA Goddard Space Flight Center, has been shown to have a beneficial effect on both the accuracy of the 6-hour assimilation model forecast and that of the retrievals. More importantly, the negative impacts on medium range forecasts over the Northern Hemisphere are, for the most part, eliminated (Susskind and Pfaendtner, 1989). In addition to temperature profiles and precipitable water estimates, a wide range of geophysical parameters (e.g., land and sea surface temperature, ice and snow extent, cloud top pressure and amount, and estimates of outgoing long wave radiation, soil moisture, total ozone, and precipitation) can be produced. A particularly strong point with the interactive approach is that the above parameters are obtained in a way which is consistent with the mass and wind fields in the assimilation because the 6-hour forecast from the assimilation is used as the first guess for the retrievals. Therefore, not only is an accurate, self-consistent set of data produced for numerical weather forecasting, a powerful climate monitoring system is also created.

2. Proposed Strategy

There was a general agreement among the Workshop participants that the various sophisticated inversion methods (e.g., the NESDIS operational system (Fleming et al., 1986b, 1988); the NASA research scheme (Susskind et al., 1984)) should have about the same accuracy, given the same radiances. There was also a strong consensus that the most accurate first guess possible should be used for the inversion problem. Over most areas of the globe that is most likely a forecast provided by a general circulation model during the data assimilation. In areas where the model forecast might be poor as determined by comparing observed (satellite) and computed (model) radiances from the forward problem, a classification approach (i.e., McMillin, 1986b) blended with the model first guess, seems promising.

The Workshop participants strongly agreed that the most important remaining weakness (assuming the use of a forecast first guess) in the NESDIS operational system was in the approach used for cloud-clearing, where an angle correction (to nadir) is performed before cloud-clearing, and hence, the angle correction procedure must also simultaneously account for clouds. All the participants agreed that the most accurate off-nadir retrievals are produced if the off-nadir radiances are cloud-cleared at the same angle that the satellite views the atmosphere (as in the NASA scheme). In addition, the NASA scheme also uses the forecast temperature information in the cloud-clearing, while the NESDIS scheme does not use this information. On the other hand, a limitation identified in the NASA retrieval scheme was in not utilizing the SSU data for the stratospheric sounding problem, as is done in the NESDIS system.

Various aspects of the NESDIS and GLA retrieval schemes will be intercompared and tested. Retrievals from a combined system will be evaluated using collocated radiosondes, and by conducting forecast impact tests with the NMC global data assimilation system (GDAS). Additional forecast impact tests will then be conducted in parallel to the operational system in real time with the combined retrieval scheme.

With the above considerations in mind, the Workshop participants recommended the following steps in order to combine the strengths of the different approaches:

1. NESDIS and NASA will exchange retrieval software.

2. Both retrieval systems will be implemented on the NMC CRAY YMP for experimentation.

3. The NASA approach for cloud-clearing (producing cloud-cleared radiances at the angles of observation) will be tested by NESDIS (but without iteration as in the NASA system).

4. NASA will provide NESDIS cloud-cleared radiances; NESDIS will produce retrievals; NMC will evaluate the analysis/forecast impact.

5. NASA will conduct tests to determine the sensitivity of its cloud-clearing scheme to the number of iterations. Cloud-cleared radiances computed from the first guess, after one iteration, and after the full adjustment made in the NASA system, will be provided to NESDIS for comparison.

6. NESDIS will implement their bias correction (on observed radiances during the forward problem) in the NASA code. This will be compared with the NASA approach.

7. Other aspects of the retrieval problem will also be evaluated, such as the ability to retain an accurate first guess and improve a poor one.

The initial thrusts of the joint project involve: 1) exporting the NASA approach for cloud-clearing to NESDIS for evaluation, and, 2) developing the capability to combine ar air-mass classification guess with the NMC 6 hour forecast guess in regions where the forward calculation differences are large.

3. NESDIS/NMC Pilot Study

A joint NESDIS/NMC pilot effort was initiated in early 1989 to develop an interactive retrieval system.

Phase II of the pilot effort is now underway which involves developing the capability to retrieve temperature and specific humidity at the NMC model levels. This has two advantages: 1) the error due to vertical interpolation of the model 6-hour forecast to the levels where the retrievals are produced (previously, constant pressure levels) is eliminated, and, 2) the new NMC global spectral interpolation (SSI) objective analysis scheme (Parrish and Derber, 1991), which was implemented on June 25, 1991, performs the analysis at the model levels, which also eliminates a source of error.

The retrieval code has now been ported to the CRAY YMP and parallel analysis/forecast experiments conducted at T62 resolution. A full resolution (T126) impact test will be conducted soon, with operational implementation anticipated in early 1992. Enhancements to the pilot system, as discussed above (e.g., the hybrid model first guess - classification approach, use of the NASA cloud clearing, etc.), will be implemented following successful parallel analysis/forecast experiments on the NMC CRAY YMP.

4. Acknowledgments

This document is largely a synopsis of a proposal recently approved by NASA, NESDIS, and NMC and reflects the consensus views, represented in the proposal, of the other Co-PI's (C. Hayden, J. Susskind), the Co-I's (H. Fleming, M. Goldberg, L. McMillin, J. Pfaendtner, A. Reale), and the Collaborators (M. Chahine, E. Kalnay, G. Ohring, W. Smith). Their input is gratefully acknowledged. The excellent technical support provided by B. Katz of General Sciences Corporation and J. Daniels of ST Systems Corporation with the NESDIS/NMC pilot study is sincerely appreciated.

5. References

Baker, W.E., R. Atlas, M. Halem, and J. Susskind, 1984: A cast study of forecast sensitivity to data and data analysis techniques. Mon. Wea. Rev., 112, 1544-1561.

Fleming, H. E., M. D. Goldberg, and D. S. Crosby, 1986b: Minimum variance simultaneous retrieval of temperature and water vapor from satellite radiance measurements. Preprints Second Conference on Satellite Meteorology/Remote Sensing and Applications, 13–16 May, Williamsburg, VA, Amer. Meteor. Soc., Boston, pp. 20-23.

Fleming, H.E., M. D. Goldberg and D. S. Crosby, 1988: Operational implementation of the minimum variance simultaneous retrieval method. Preprints Third Conference on Satellite Meteorology and Oceanography, 31 January - 5 February, Anaheim, CA, pp. 16-19.

McMillin, L. M., 1986b: The use of classification procedures to improve the accuracy of satellite soundings of temperature and moisture. Preprints Second Conference on Satellite Meteorology/Remote Sensing and Applications, 13-16 May 1986, Williamsburg, VA. Amer. Meteor. Soc., Boston, 1-4.

Parrish, D. F., and J. C. Derber, 1991: The National Meteorological Center's spectral statistical interpolation analysis system. NMC Office Note 379.

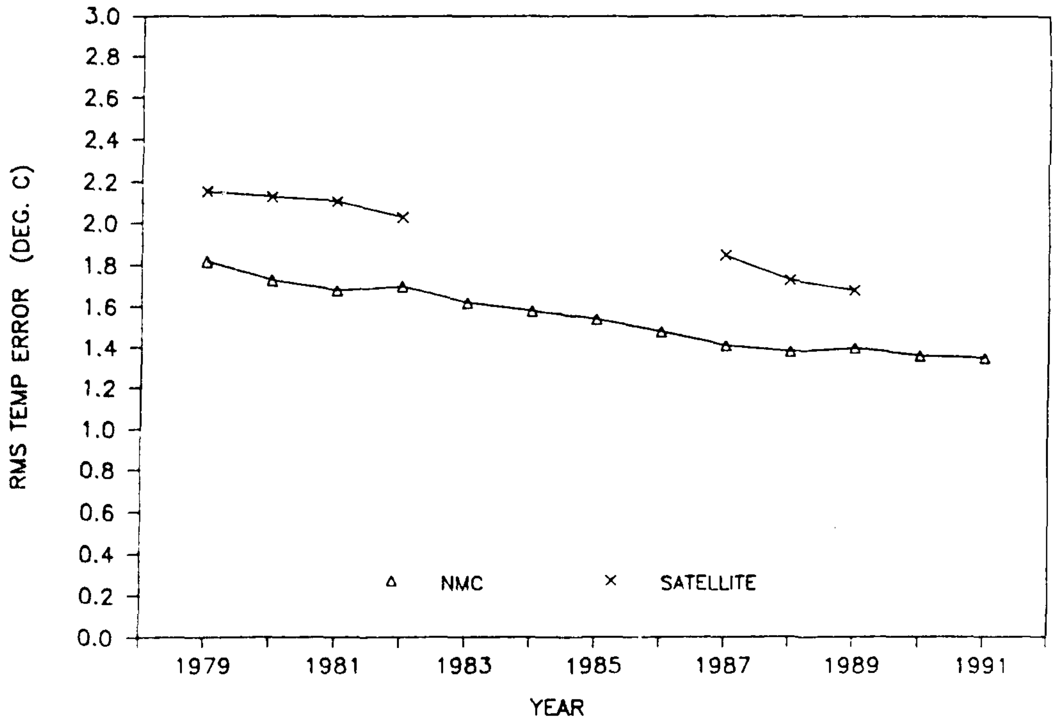
Susskind, J., J. Rosenfield, D. Reuter, and M. T. Chahine, 1984: Remote sensing of weather and climate parameters from HIRS2/MSU on TIROS-N. J. Geophys. Res., 89D, 4677-4697.

Susskind, J., and J. Pfaendtner, 1989: Impact of interactive physical retrievals on NWP. ECMWF/EUMETSAT Workshop on the Use of Satellite Data in Operational NWP, 8-12 May, Reading, 245-300.

Joint NESDIS/NASA/NMC Effort to Develop an Advanced Satellite Retrieval System

Co-P.I.'s:	**W. Baker** **C. Hayden** **J. Susskind**
Co-I's:	**H. Fleming** **M. Goldberg** **L. McMillin** **J. Pfaendtner** **A. Reale**
Collaborators:	**M. Chahine** **J. Derber** **E. Kalnay** **G. Ohring** **W. Smith**

500 MB RMS TEMP ERROR FOR NORTHERN HEMISPHERE:
6–HOUR FORECAST VS SATELLITE RETRIEVAL



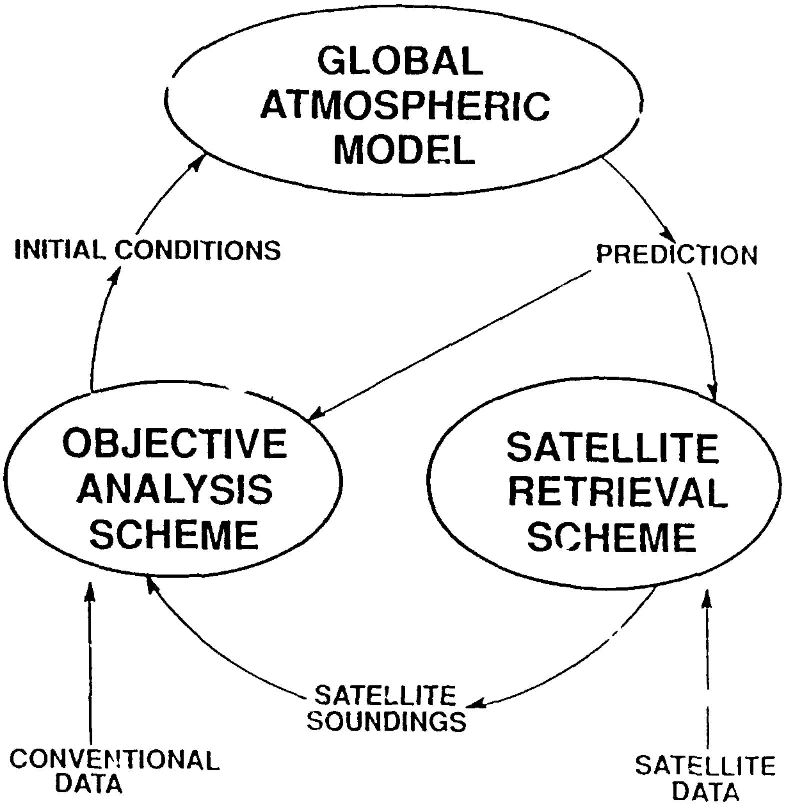
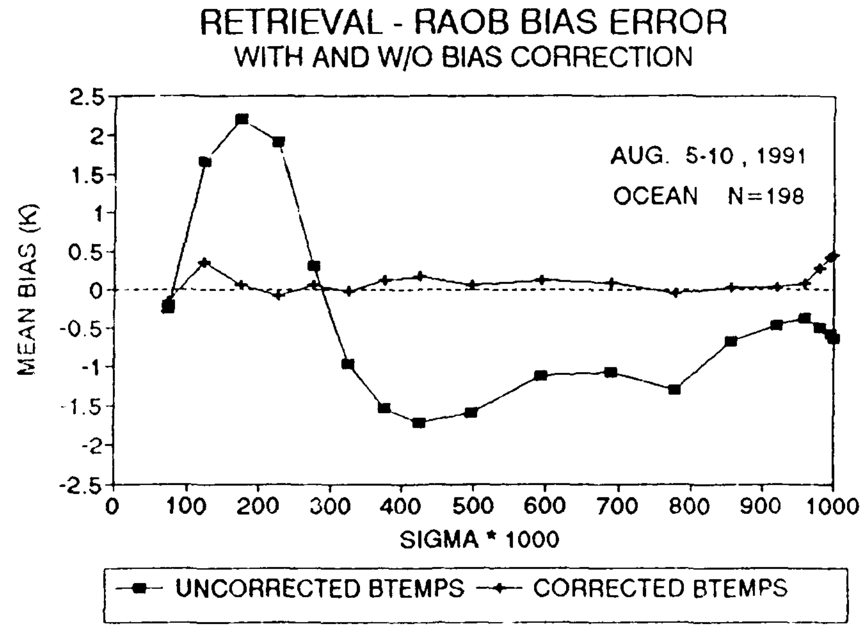
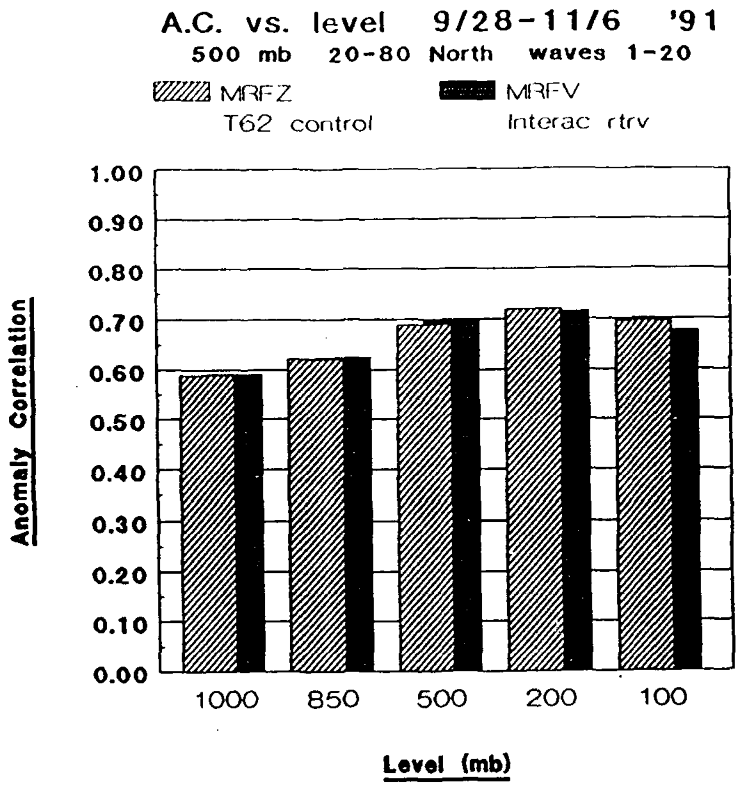


Fig. 1 Schematic diagram of an interactive analysis/forecast/retrieval system under joint development by NESDIS and NMC.




A.C. vs. level 9/28-11/6 '91
500 mb 20-80 North waves 1-20
MRFZ
T62 control
MRFV
Interac rtrv
Anomaly Correlation
1.00
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0.80
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0.60
0.50
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0.10
0.00
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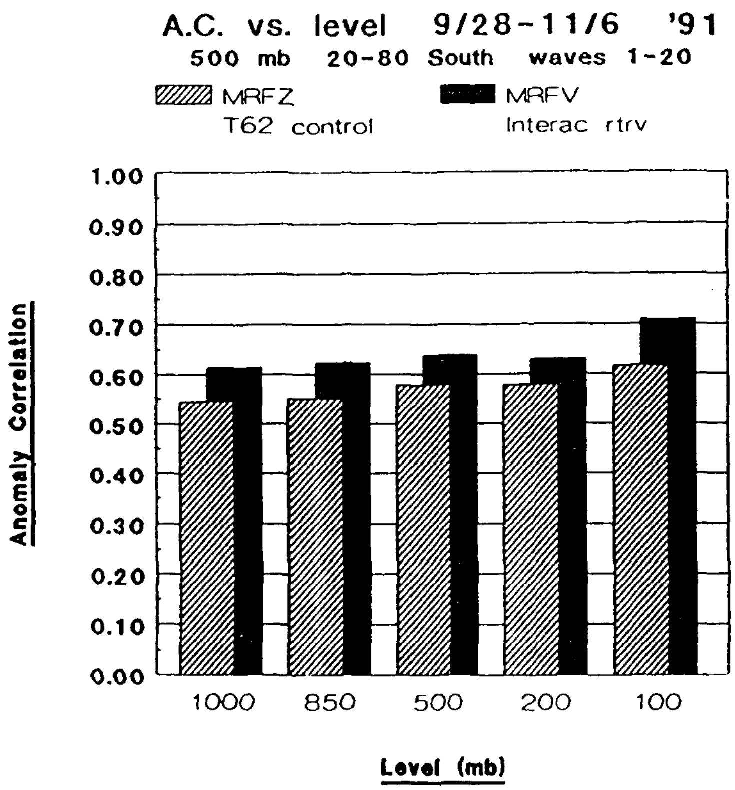
500
200
100
Level (mb)


A.C. vs. level 9/28-11/6 '91
500 mb 20-80 South waves 1-20
MRFZ
T62 control
MRFV
Interac rtrv
Anomaly Correlation
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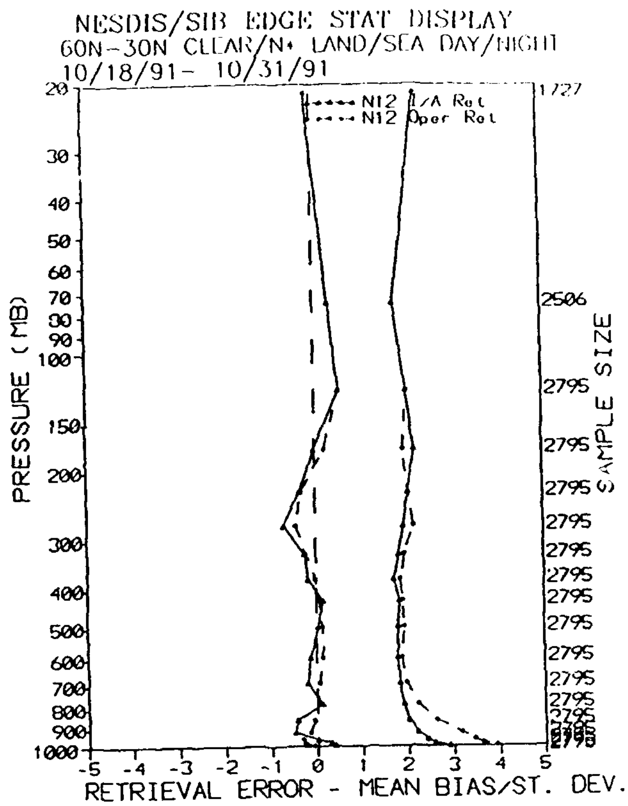
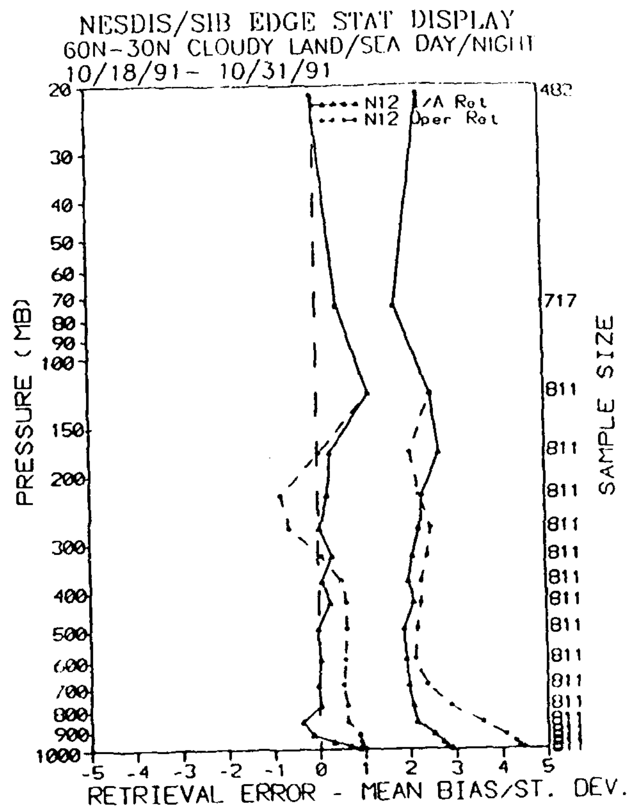
Level (mb)


NESDIS/SIB EDGE STAT DISPLAY
60N-30N CLEAR/N+ LAND/SEA DAY/NIGHT
10/18/91- 10/31/91
N12 I/A Rot
N12 Oper Rot
PRESSURE (MB)
SAMPLE SIZE
RETRIEVAL ERROR - MEAN BIAS/ST. DEV.


NESDIS/SIB EDGE STAT DISPLAY
60N-30N CLOUDY LAND/SEA DAY/NIGHT
10/18/91- 10/31/91
N12 I/A Rot
N12 Oper Rot
PRESSURE (MB)
SAMPLE SIZE
RETRIEVAL ERROR - MEAN BIAS/ST. DEV.

Concluding Remarks

Implementation of the interactive retrievals represents a significant enhancement in our ability to fully utilize satellite radiances for NWP. However, further work remains in several areas:

- Air–mass classification
- Cloud–clearing
- Use of error covariance matrix at each gridpoint
- Enhanced water vapor retrievals
- Other retrieved parameters (i.e., precipitation)

CLASSIFICATION RETRIEVAL APPROACHES FOR DMSP

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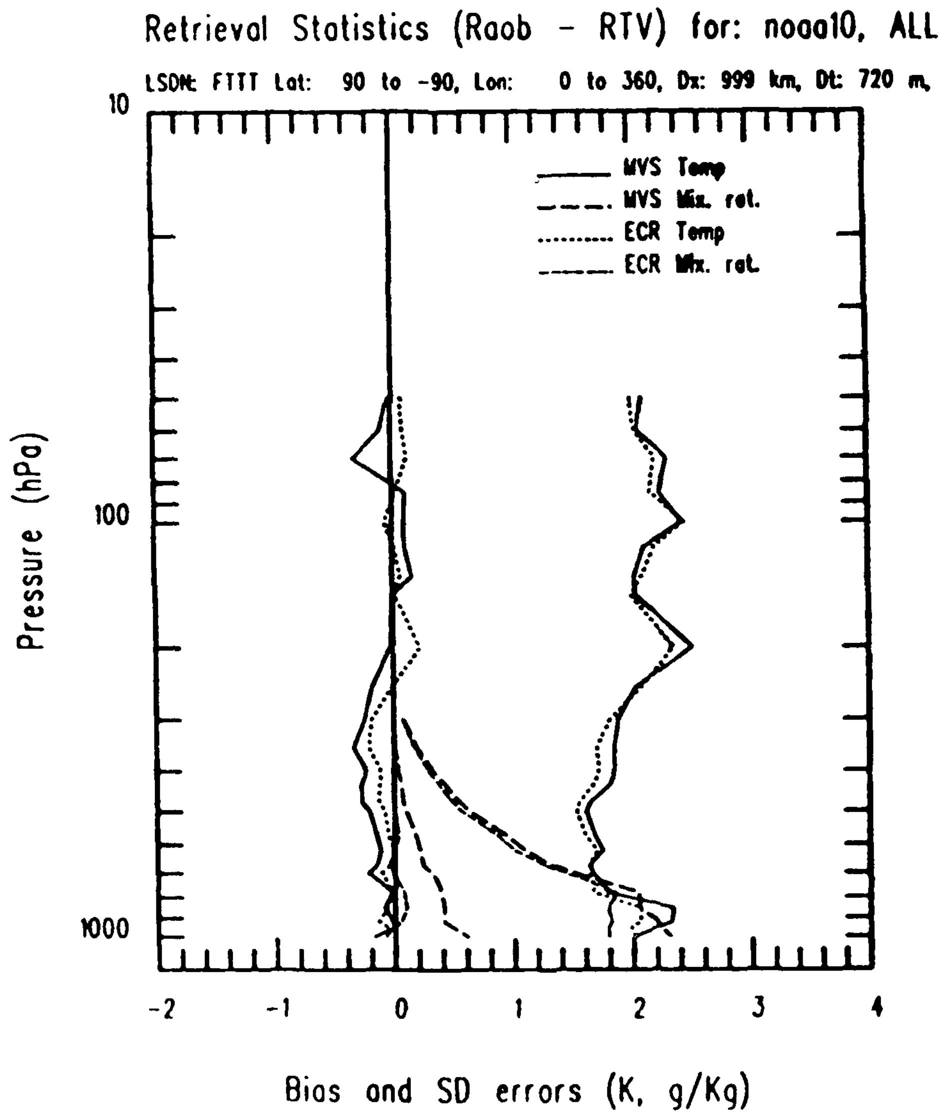
Classification methods have been used to derive temperature and water vapor profiles from satellite radiances measured by the TIROS Operational Vertical Sounder (TOVS). When compared to approaches that start with a climatological first guess, the classification approaches have demonstrated an ability to recover more of the information available in the radiances and increase the accuracy of the resulting retrievals by 0.2 to 0.3 K rms (see McMillin 1991). The empirical classification regression described by McMillin has been successfully applied to microwave data from the MSU sensor with similar results. At this meeting, results of the method using SSMT data will be presented. In addition, comparisons of this classification approach with alternative classification approaches will be discussed.

McMillin, L.M., 1991: Evaluation of a Classification Method for Retrieving Atmospheric Temperatures from Satellite Measurements, *J. Appl. Meteor.*, **30**, 432-446.

Classification Retrieval Approaches for DMSP

Larry McMillin

National Environmental Satellite, Data, and Information Service
Satellite Research Laboratory
Washington, DC



Overview of Method

1. Calculate an average temperature for the profile
2. Adjust the measured radiances
3. Calculate the principal component scores of the eigenvectors
4. Calculate the class index
5. Get the class mean temperature and radiance
6. Apply the regression coefficients

Calculate the average temperature for the profile

1. Temperature is unknown so average radiances
2. Average channels 1,2,3,5,6,10
3. Denote the sample average by "A"

Adjust the Measured Radiances

1. Subtract the profile average from all radiances
2. $V^* = T^* - A - \overline{V}^*$

   T^* is the vector of radiance temperatures

   $\overline{V}^*$ is the average for the dependent sample

Calculate the Principal Component Scores

1. Multiply the adjusted radiances by the eigenvector coefficients for channels 1-6 and 10.

2. $\alpha = EV^*$

   α are principal component scores

   E are the eigenvector coefficients

Calculate the Class Index

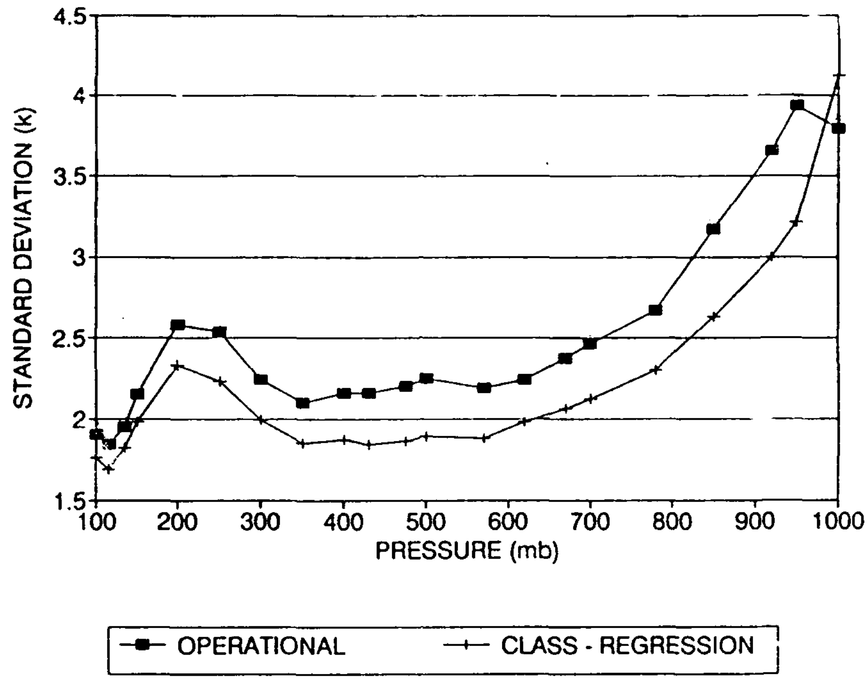
1. Use 4 eigenvectors
2. 14 divisions for the 1st
3. 4 for the second
4. 2 for the third
5. 2 for the fourth

Get the Class Mean Temperature and Radiance

1. The class means are generated from a sample of collocations.

   $\bar{T}(c)$ are the mean temperatures for the class

   $T^*(c)$ are the mean brightness temperatures for the class



CONCLUSIONS

1. A CLASSIFICATION - REGRESSION SYSTEM PRODUCES A SIGNIFICANT (SEVERAL TENTHS OF A DEGREE) INCREASE IN ACCURACY OVER THE CURRENT OPERATION.

USING SSM/T DATA AS PROOF OF CONCEPT FOR AN AMSU-A RETRIEVAL ALGORITHM

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Brightness temperature data from DMSP/SSM/T have been used as proof of concept for a proposed AMSU-A operational retrieval algorithm. The algorithm is for the simultaneous retrieval of the atmospheric temperature profile, the surface temperature, and the surface emissivity. The solution is based on the minimum variance method, which minimizes the expected mean-square error for a linear unbiased estimate. Since the brightness temperature observations sense these meteorological parameters simultaneously, retrieving them simultaneously guarantees that the solution satisfies the radiance.

Surface temperature and emissivity occur as a product in the boundary term of the radiative transfer equation, therefore, this product is retrieved as a single parameter, and then typically the surface temperature is obtained from some independent source and divided into the retrieved product to extract the surface emissivity. A novel feature of our method is that we retrieve these two parameters separately using only the brightness temperature measurements, i.e., independent knowledge of the surface temperature is not required. The deri ation of this procedure, based on the minimum variance approach, will be presented. Results will be given to demonstrate the validity of the retrieval algorithm.

USING SSM/T DATA AS PROOF OF CONCEPT FOR AN AMSU-A RETRIEVAL ALGORITHM

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$$T_i = (\epsilon \cdot t_s)\ \tau_i(p_s) + \int_{\tau_s}^{1} t(p)\ d\tau_i(p,\epsilon)$$

T_i = ith chan. brightness temperature

ϵ = surface emissivity @ 50.5 GHz

$t(p)$ = atmospheric temperature profile

t_s = surface (skin) temperature

$\tau_i(p)$ = ith chan. standard transmittance

$\tau_i(p,\epsilon)$ = effective transmittance, where

$$\tau_i(p,\epsilon) = \{1 - [1 - \epsilon][\tau_i(p_s)/\tau_i(p)]^2\}\tau_i(p)$$

MANIPULATION OF THE RADIATIVE TRANSFER EQ.

1. Assume the initial guess $\bar{\tau} \approx \tau$

2. Subtract the initial state RTE from the exact RTE

3. Let $\delta x = x - \bar{x}$ for any quantity x

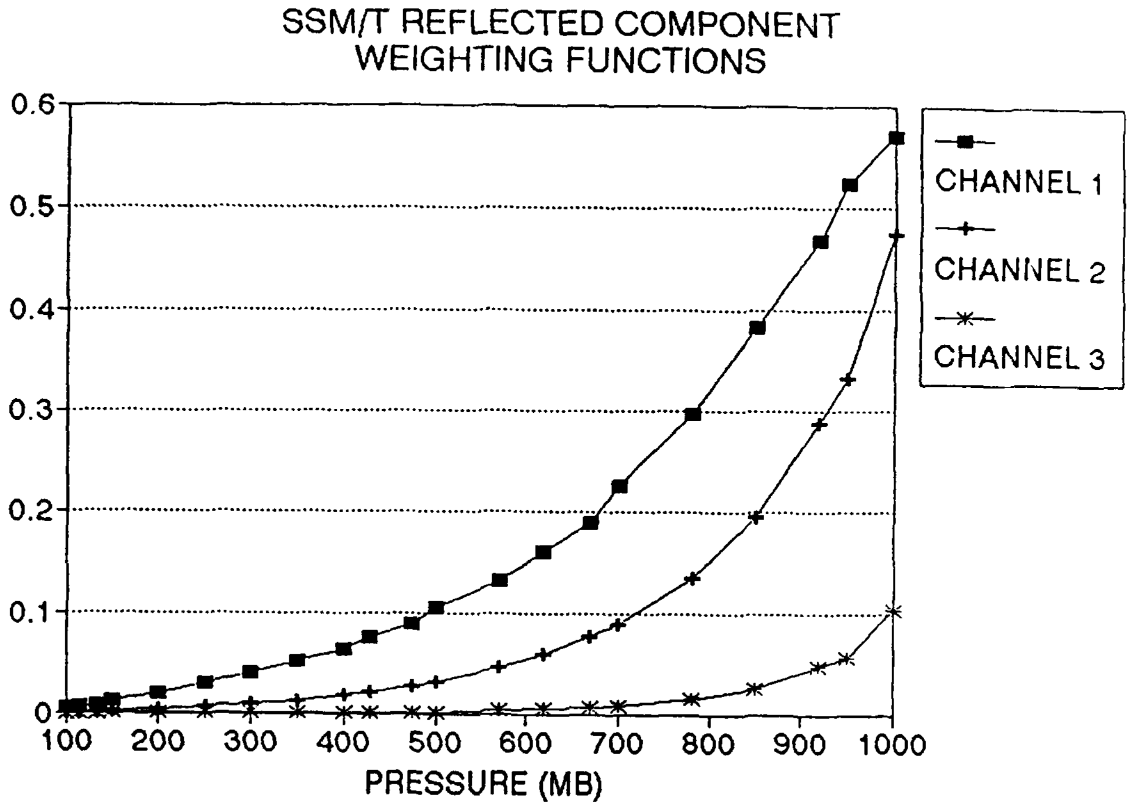
4. Set $\epsilon = \bar{\epsilon} + \delta\epsilon$ in $d\tau_i(p,\epsilon)$

5. Reflectivity $r = 1 - \epsilon$, hence $-\delta\epsilon = \delta r$

$$\delta T_i = \delta(\epsilon t_s)\ \tau_i(p_s) + \int_{\tau_s}^{1} \delta t(p)\ d\tau_i(p,\bar{\epsilon})$$

$$- \delta\epsilon \int_{\tau_s}^{1} t(p)\ [\tau_i(p_s)/\tau_i(p)]^2\ d\tau_i(p)$$

$$t^*_i = - \int_{\tau_s}^{1} \bar{t}(p)\ \{[\tau_i(p_s)/\tau_i(p)]^2\ d\tau_i(p)\}$$



$$\vec{\delta T} = \delta\epsilon \; \vec{t^*} + \delta(\epsilon t_S) \; \vec{\tau_S} + A \; \vec{\delta t}$$

PART I

Let $\epsilon = \overline{\epsilon}$, then

$$\vec{\delta T} = \delta(\epsilon t_S) \; \vec{\tau_S} + A \; \vec{\delta t}$$

PART II

Let $\vec{\delta T} - A \; \vec{\delta t} = \vec{\delta S}$, then

$$\vec{\delta S} = \delta\epsilon \; \vec{t^*} + \delta(\epsilon t_S) \; \vec{\tau_S}$$

which is an overdetermined 3 x 2 system.

TEMPERATURE AND EMISSIVITY RESULTS FROM A SSM/T RETRIEVAL ALGORITHM

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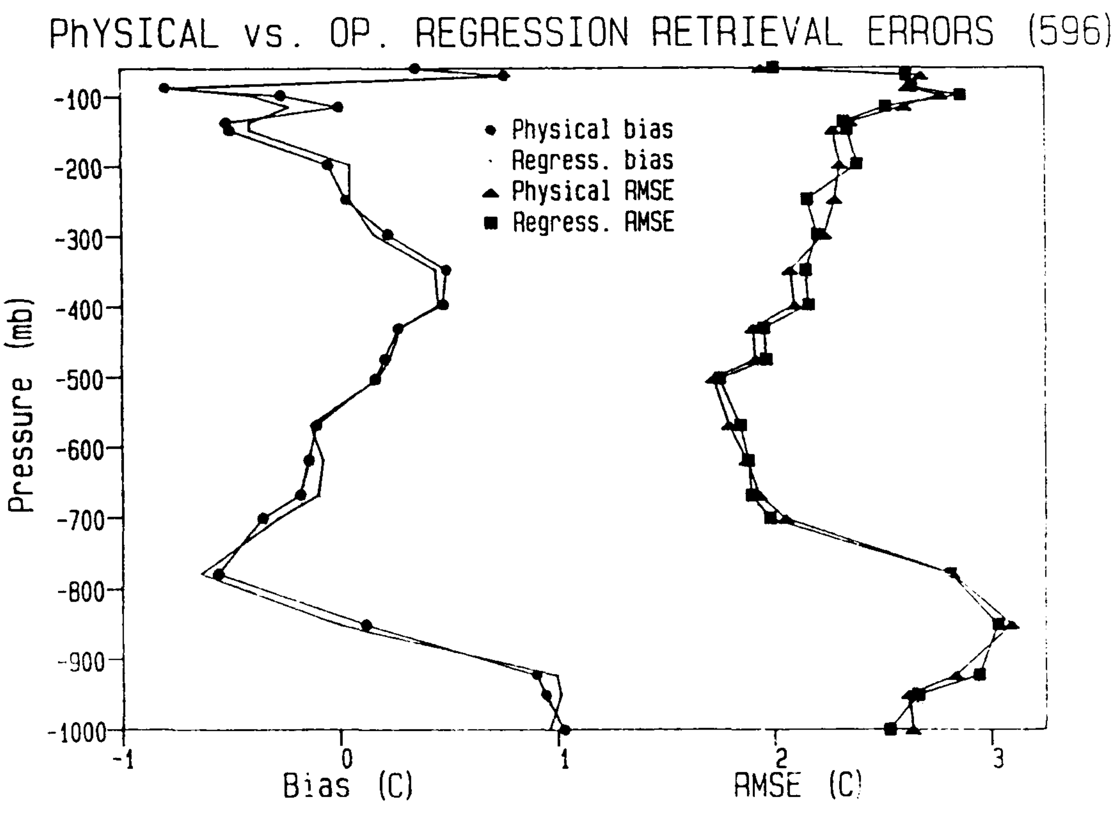
A physical retrieval algorithm has been developed utilizing DMSP SSM/T brightness temperature data. The retrieved products include atmospheric temperature profiles, the surface (skin) temperature, and the surface emissivity at 50 GHz. Only a brief description of the algorithm will be given because the emphasis of the talk will be on the accuracy of the retrieved products. Not only will the retrievals be compared with coincident radiosonde temperature profiles, but also with the NESDIS Operational Shared Processing profiles. The Shared Processing algorithm uses a linear regression approach. The physical retrieval algorithm is shown to be at least competitive with the operational retrieval algorithm, and in some cases exceeds the accuracy of the Shared Processing results. A comparative analysis of the results from the two retrieval approaches will be given.

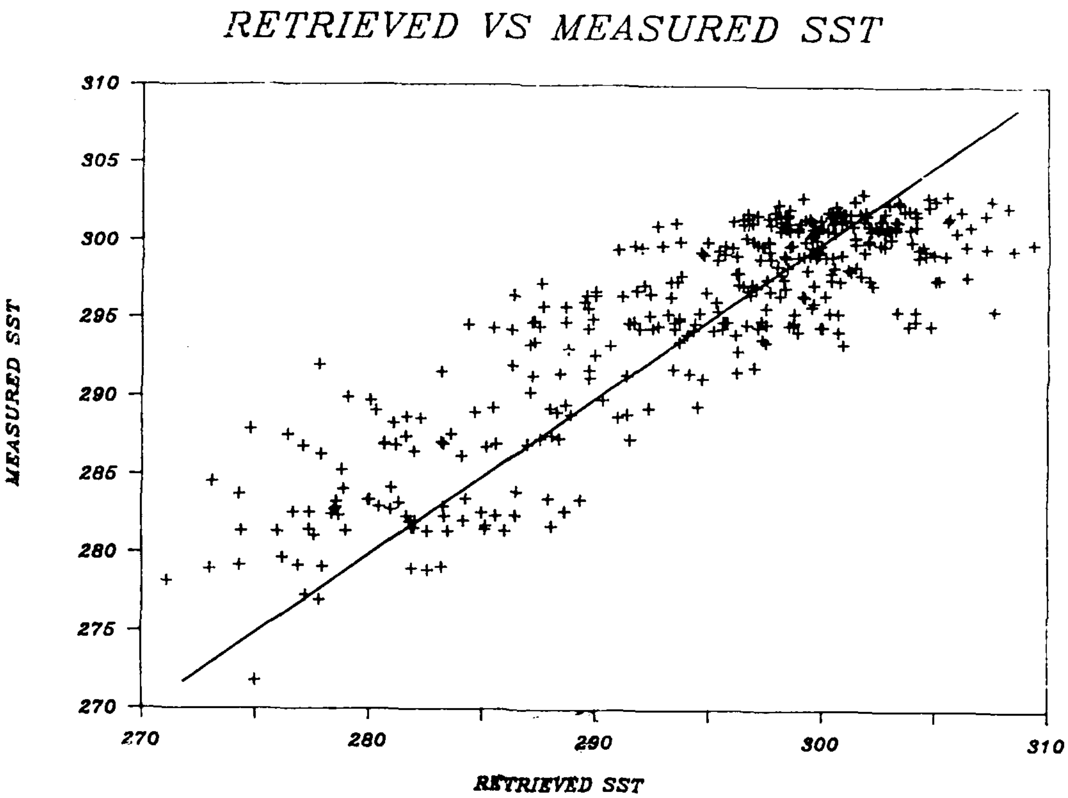
TEMPERATURE AND EMISSIVITY RESULTS

FROM A SSM/T RETRIEVAL ALGORITHM

Eugene J. Kratz
SM Systems & Research Corporation

Henry E. Fleming
Satellite Research Laboratory
NOAA/NESDIS




RETRIEVED VS MEASURED SST
MEASURED SST
RETRIEVED SST
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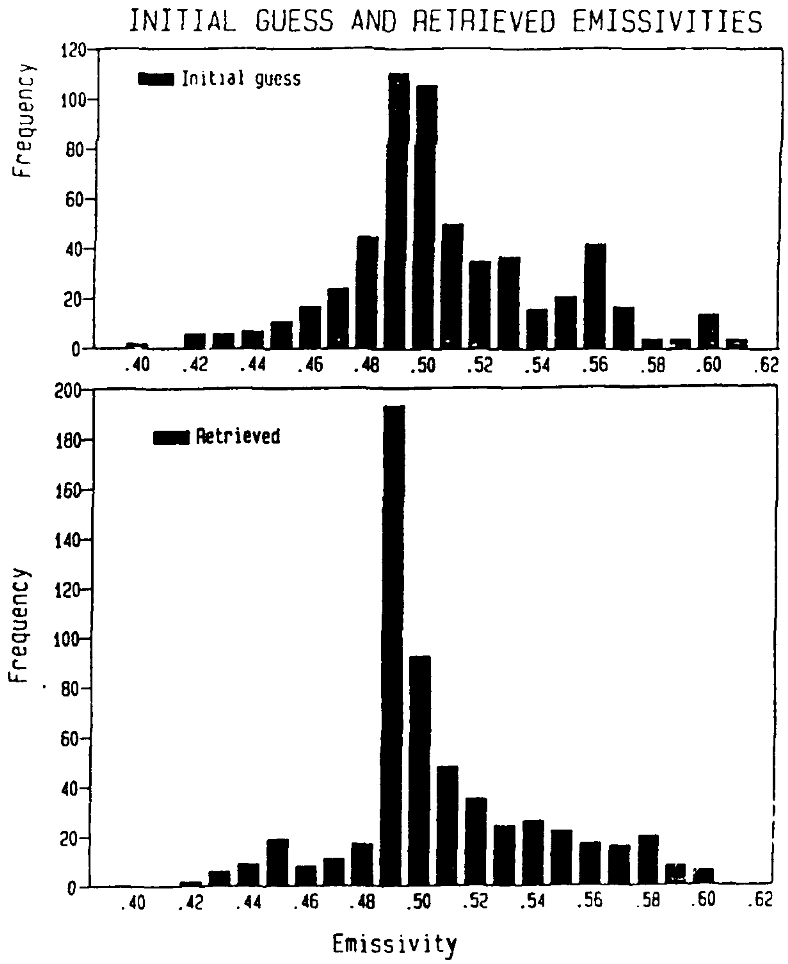
310


INITIAL GUESS AND RETRIEVED EMISSIVITIES
Initial guess
Frequency
Retrieved
Frequency
Emissivity
.40
.42
.44
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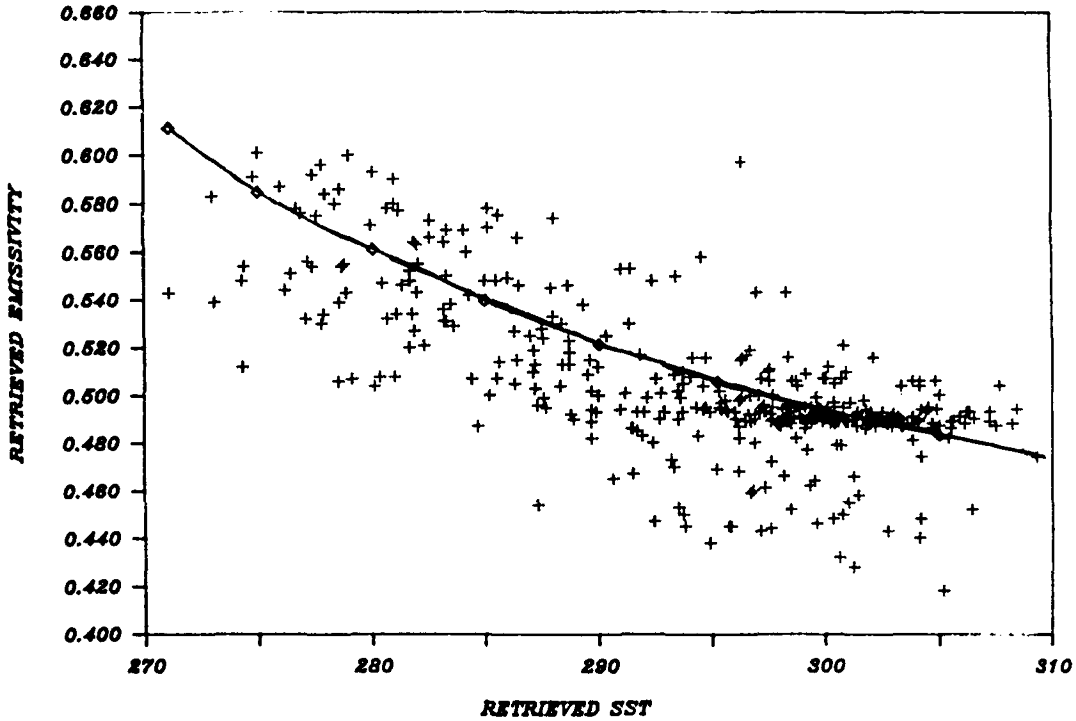
.52
.54
.56
.58
.60
.62

RETRIEVED EMISSIVITY VS RETRIEVED SST



PAINLESS EXTRACTION: SUBTRACTIVE TEMPERATURE SENSING FROM SATELLITE RADIANCES USING THE ZETA TRANSFORM

Jean I.F. King

Phillips Laboratory
Geophysics Directorate
Hanscom AFB, MA 01731-5000

The radiance integral specifies the satellite-observed flux $R(\hat{z})$ as a complex folding or convolution of the Planck temperature profile $B(z)$ with the weighting function $w(z-\hat{z})$ which represents the medium interaction. The temperature profile is then identified with the solution of a Fredholm equation of the first kind. In conventional approaches a discretization process expresses this equation as a finite sum quadrature with the matrix then inverted to yield the Planck intensity.

We pursue a different tack. A moment method is used to approximate the profiles as three interacting bilaterial wave packets. A zeta-function transform applied to the three packets reduces the complex interaction of the radiance and temperature profiles to a subtractive arithmetic operation. By eliminating the inversion operation as a source of error, we are positioned to determine the limits of retrieval accuracy imposed by the inevitable noise in the radiance observations and their number limitations. Examples will be given which quantitatively specify this noise vs. accuracy relationship.

ZETA STATE VECTOR ANALYSIS

TEMPERATURE INFERENCING REDUCED

FROM MATRIX INVERSION TO COLUMN VECTOR

ARITHMETIC

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PHILLIPS LABORATORY/GEOPHYSICS DIRECTORATE
NMC/NESDIS/DOD CONFERENCE ON
DMSP RETRIEVAL PRODUCTS
15 April 1992

RADIANCE INTEGRAL

$$R(\hat{p}) = \int_0^\infty B(p)\, W(p/\hat{p})\, \frac{dp}{p}$$

AMPLITUDE STATE VECTORS

$$R(\hat{p}) \rightarrow r_i \qquad W(p/\hat{p}) \rightarrow w_{ij} \qquad B(p) \rightarrow b_j$$

MATRIX INVERSION

$$r_i = \sum_j w_{ij} b_j \rightarrow b_j = \sum_i w_{ji}^{-1} r_i$$

RADIANCE INTEGRAL

$$R(\hat{p}) = \int_0^\infty B(p) W(p/\hat{p}) \frac{dp}{p}$$

ZETA STATE VECTORS

$$R(\hat{p}) \rightarrow r_n \qquad W(p) \rightarrow w_n \qquad B(p) \rightarrow b_n$$

COLUMN VECTOR SUBTRACTION

$$b_n = r_n - (-1)^n w_n$$

WEIGHTING FUNCTION ZETA VECTORS

$$W(p) = \frac{(a m)^{am}}{m \Gamma(am)} p^{a} e^{-amp^{1/m}}$$

$a = m = 1$ GOODY STATISTICAL $\quad W = pe^{-p} \quad \tau = e^{-p}$

$a = 1, m = 1/2$ ELSASSER $\quad W = \sqrt{\frac{2}{\pi}}\, p e^{-p^2/2} \quad \tau = \operatorname{erfc} p/\sqrt{2}$

$$\zeta_n(a,m) = \frac{1}{n!} \int_0^\infty \frac{x^{n-1} e^{-ax}}{1 - e^{-x/m}} dx = \frac{1}{n} \sum_{k=0}^{\infty} \frac{1}{(a + \frac{k}{m})^n}$$

TRICOLOR ZETA NUMBER THEOREM: THE KEY

ZETA NUMBER SET

$$\zeta_n = \frac{1}{n}\sum_{j=1}^{N}\frac{1}{a_j^{\,n}}, \quad \zeta_n \equiv r_n \quad (n = 1,2,\ldots N;\ N = 2,3,\ldots)$$

CORRESPONDING DENSITY PROFILE

$$R_n(z) = R_-(z) + R_+(z)$$

$$R_-(z) = H(-z)\sum_{i=1}^{m-1}\frac{e^{-a_i z}}{P_n'(a_i)} \quad (\mathrm{Re}\ a_i < 0)$$

$$R_+(z) = -H(z)\sum_{i=m}^{n}\frac{e^{-a_i z}}{P_n'(a_i)} \quad (\mathrm{Re}\ a_i > 0)$$

FROM DENSITY PROFILE TO ZETA SET

$$R(z) \rightarrow \tau_n\ (\text{moments}) \rightarrow \zeta_n = r_n \qquad \tau_n = \frac{1}{n!}\int_{\infty}^{\infty} z^n R(z)\, dz$$

FROM ZETA SET TO DENSITY PROFILE

$$r_n = \zeta_n \rightarrow \lambda_n \rightarrow a_j \rightarrow R_n(z)$$

SIMILARLY FOR $g_n = \zeta_n$, G_n AND $b_n = \zeta_n$, B_n PAIRS

$L \rightarrow G_T \quad \lambda_5 = C_5(\tau_i) = 4!\frac{\tau_1^3}{3!}\tau_2 + 2!\tau_1\tau_4 + 2!\tau_2\tau_3 - 5!\frac{\tau_1^5}{5!} - 3!\frac{\tau_1^2}{2!}\tau_3 - 3!\tau_1\frac{\tau_2^2}{2!} - \tau_5$

$G_T \rightarrow L \quad \tau_5 = C_5^*(\lambda_i) = 4!\frac{\lambda_1^3}{3!}\lambda_2 + 2!\lambda_1\lambda_4 + 2!\lambda_2\lambda_3 - 5!\frac{\lambda_1^5}{5!} - 3!\frac{\lambda_1^2}{2!}\lambda_3 - 3!\lambda_1\frac{\lambda_2^2}{2!} - \lambda_5$

$G_T \rightarrow S \quad \zeta_5 = S_5(\lambda_i) = 3!\frac{\lambda_1^3}{3!}\lambda_2 + \lambda_1\lambda_4 + \lambda_2\lambda_3 - 4!\frac{\lambda_1^5}{5!} - 2!\frac{\lambda_1^2}{2!}\lambda_3 - 2!\lambda_1\frac{\lambda_2^2}{2!} - \lambda_5$

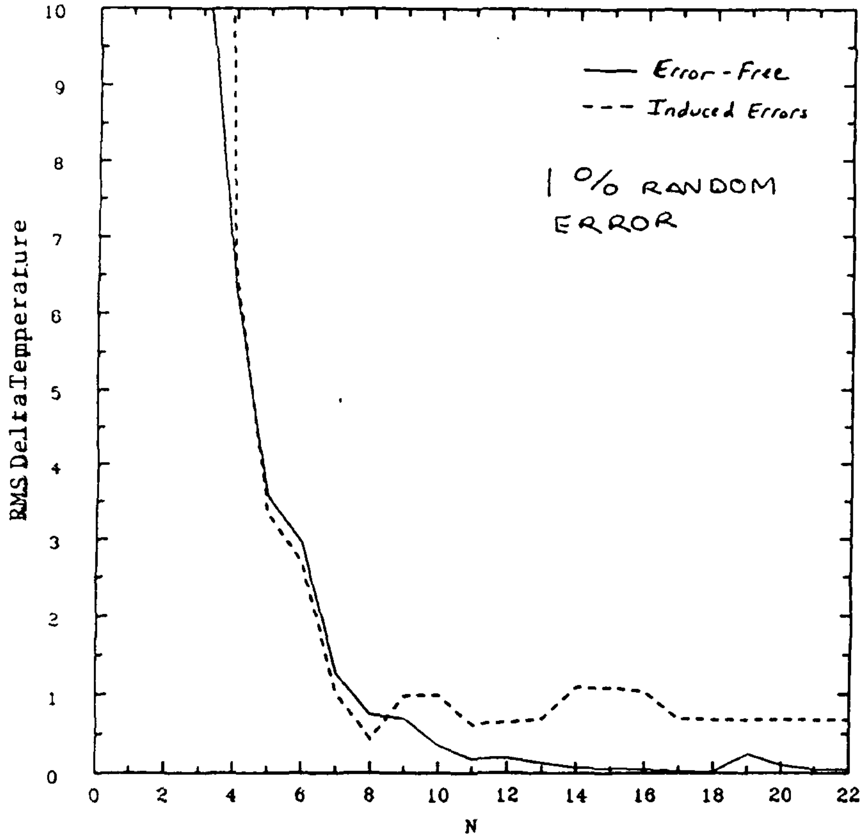
$L \rightarrow S \quad \zeta_5 = S_5^*(\tau_i) = -3!\frac{\tau_1^3}{3!}\tau_2 - \tau_1\tau_4 - \tau_2\tau_3 + 4!\frac{\tau_1^5}{5!} + 2!\frac{\tau_1^2}{2!}\tau_3 + 2!\tau_1\frac{\tau_2^2}{2!} + \tau_5$

$P \rightarrow G_T \quad \lambda_5 = S_5^*(\epsilon_i) = -3!\frac{\epsilon_1^3}{3!}\epsilon_2 - \epsilon_1\epsilon_4 - \epsilon_2\epsilon_3 + 4!\frac{\epsilon_1^5}{5!} + 2!\frac{\epsilon_1^2}{2!}\epsilon_3 + 2!\epsilon_1\frac{\epsilon_2^2}{2!} + \epsilon_5$

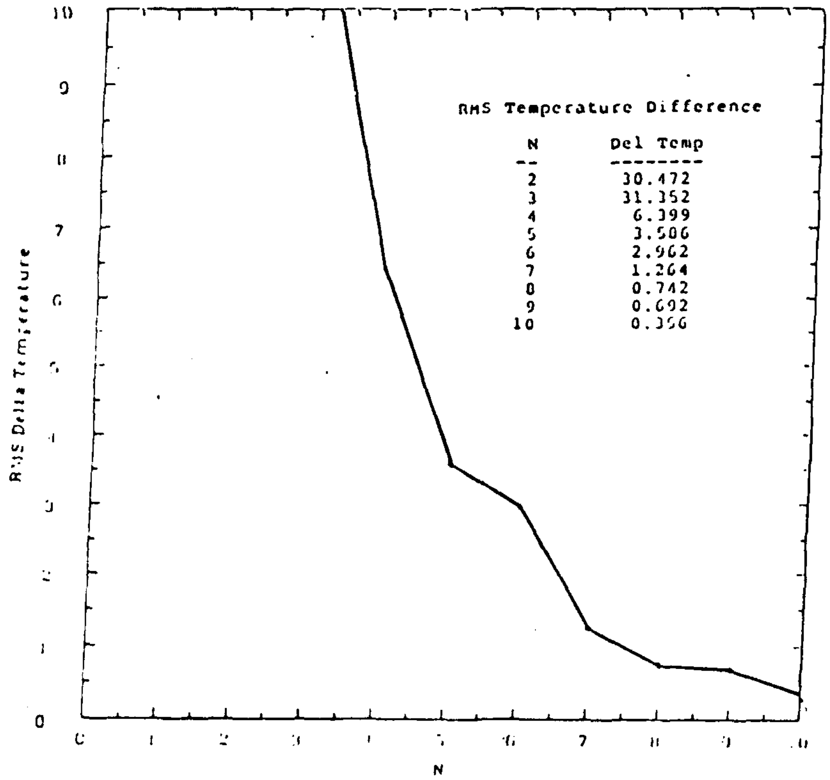
$S \rightarrow L \quad \tau_5 = E_5(\zeta_i) = \frac{\zeta_1^3}{3!}\zeta_2 + \zeta_1\zeta_4 + \zeta_2\zeta_3 + \frac{\zeta_1^5}{5!} + \frac{\zeta_1^2}{2!}\zeta_3 + \zeta_1\frac{\zeta_2^2}{2!} + \zeta_5$

$G_T \rightarrow P \quad \epsilon_5 = E_5(\lambda_i) = \frac{\lambda_1^3}{3!}\lambda_2 + \lambda_1\lambda_4 + \lambda_2\lambda_3 + \frac{\lambda_1^5}{5!} + \frac{\lambda_1^2}{2!}\lambda_3 + \lambda_1\frac{\lambda_2^2}{2!} + \lambda_5$

$S \rightarrow G_T \quad \lambda_5 = E_5^*(\zeta_i) = \frac{\zeta_1^3}{3!}\zeta_2 + \zeta_1\zeta_4 + \zeta_2\zeta_3 - \frac{\zeta_1^5}{5!} - \frac{\zeta_1^2}{2!}\zeta_3 - \zeta_1\frac{\zeta_2^2}{2!} - \zeta_5$



PHYSICALLY RETRIEVED TEMPERATURE ACCURACY VS. NO. OF RADIANCE MOMENTS (ZETA TRANSFORM METHOD)



N	Del Temp
2	30.472
3	31.352
4	6.399
5	3.506
6	2.962
7	1.264
8	0.742
9	0.692
10	0.356

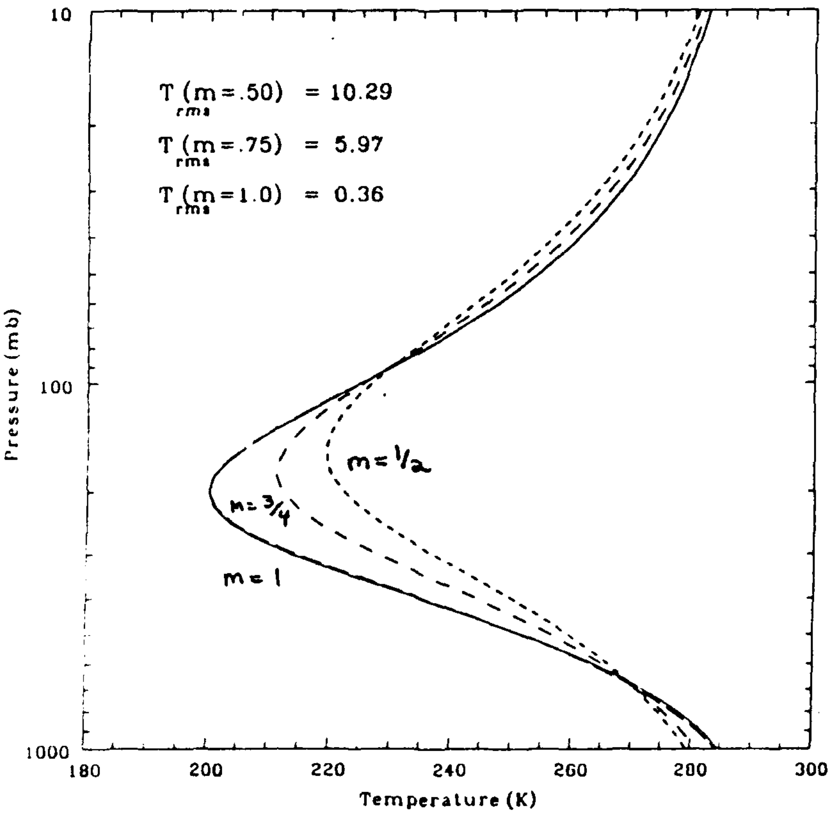
RADIANCE MOMENTS

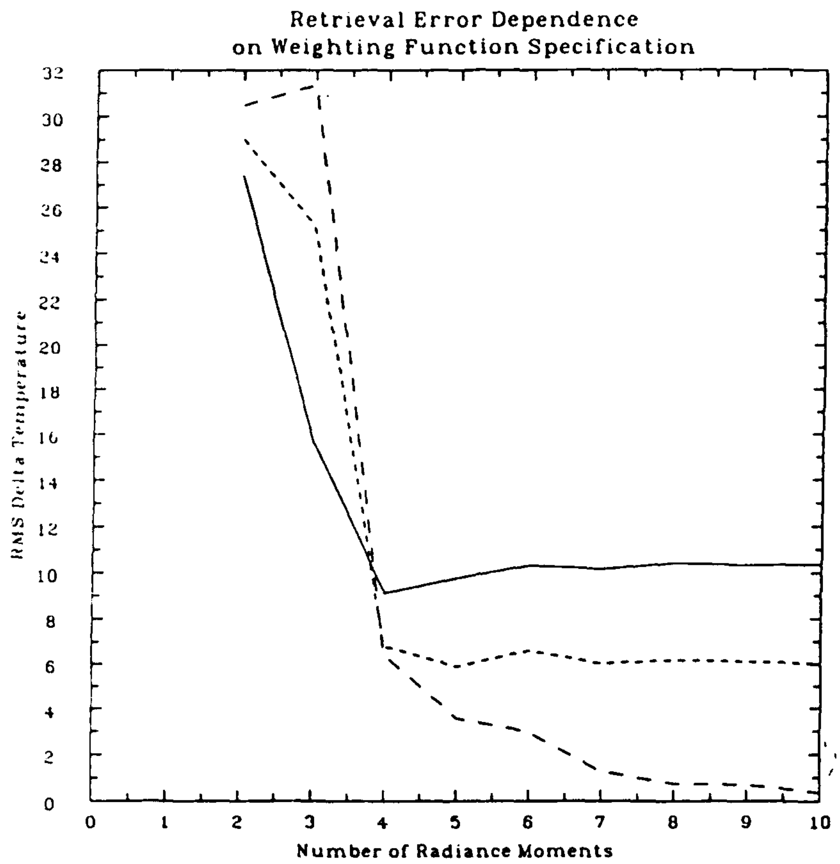
Weighting Function Dependence on Inferred Profile
Elsasser Weighting Function (m=0.5)

$$\zeta_B = \zeta_R - (-1)^n \zeta_G$$

Radiance Moment	ζ_R	ζ_G	ζ_B
0	0.00000	0.00000	0.00000
1	0.00000	0.63518	0.63518
2	1.64493	0.61685	1.02808
3	0.00000	0.35060	0.35060
4	0.54116	0.25367	0.28749
5	0.00000	0.20090	0.20090
6	0.33911	0.16691	0.17220
7	0.00000	0.14292	0.14292
8	0.25102	0.12502	0.12600
9	0.00000	0.11112	0.11112
10	0.20020	0.10000	0.10020

Retrieval Error Dependence
on Weighting Function Specification





ZETA VECTOR ANALYSIS MAKES POSSIBLE

- REDUCTION OF INVERSION TO COLUMN ARITHMETIC
- SOLUTION OF BLACK BOX PROBLEM
- ANALYSIS OF RETRIEVAL SENSITIVITY AND ACCURACY
- INTERACTIVE INVERSION

SSM/I MEASUREMENTS AS PREDICTORS OF THE RESPONSE OF AMSU-A TO SURFACE AND ATMOSPHERIC PHENOMENA

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SSM/I measures at four frequencies, 19, 22, 37 and 85 GHz, which covers a range similar to the 24, 31, 50 and 89 GHz window channels on AMSU-A. There are differences in incidence angle (constant 53° for SSM/I; varying for AMSU-A) and polarization (V and H, except V only at 22 GHz, for SSM/I; mixed linear, depending on scan position for AMSU-A), but these differences can be reconciled with the aid of some reasonable assumptions about angle and polarization dependence. Thus, SSM/I data yields information about signatures of surface phenomena such as rough seas, ice and snow, and atmospheric phenomena such as precipitation, that will be relevant to the interpretation of measurements to be made by AMSU-A.

	SSM/I	AMSU-A
WINDOW FREQUENCIES	19, 22, 37, 86 GHZ	2[illegible], 31, 50, 89 GHz
POLARIZATIONS	V, H (EXCEPT 22)	ROTATES FROM -48° TO +48°
INCIDENCE ANGLE	53°	VARIES FROM 2° TO 57°

WINDOW CHANNELS -

RADIATIVE TRANSFER MODEL (NON-SCATTERING):

SURFACE AT T_S WITH EMISSIVITY ε

ISOTHERMAL ATMOSPHERE AT T_a

T SCALE DEFINED SO $T_{COSMIC} = 0$

$$T_B = T_a + t^2 (\varepsilon T_S - T_a)$$

TRANSMITTANCE OF THE ATMOSPHERE:

$$t^2 = \text{EXP}\{-[\alpha(\nu,T_a) + \beta(\nu,T_a)V + \gamma(\nu,T_a)L]/\mu\}$$

$V = H_2O$ VAPOR BURDEN

$L =$ LIQUID H_2O BURDEN

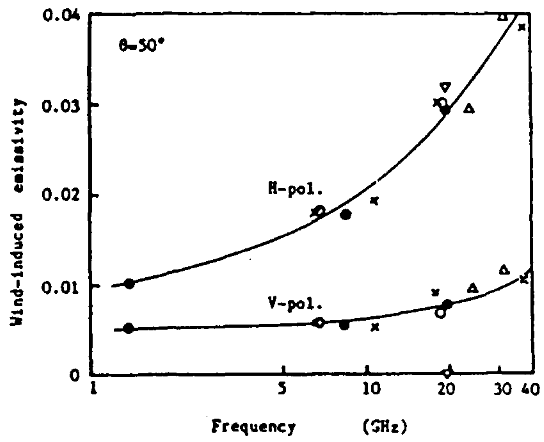


Fig. 8. Comparison of dependency of emissivity change due to wind of speed of 10 m/s in both polarizations on frequency.

- ○ Sasaki *et al.* (6.7, 18.6 GHz)
- △ Isozaki *et al.* (23.8, 31.4 GHz)
- ● Hollinger (1.41, 8.36, 19.34 GHz)
- ▽ Stogryn (19.4 GHz)
- × Wentz (6.63, 10.69, 18, 37 GHz)

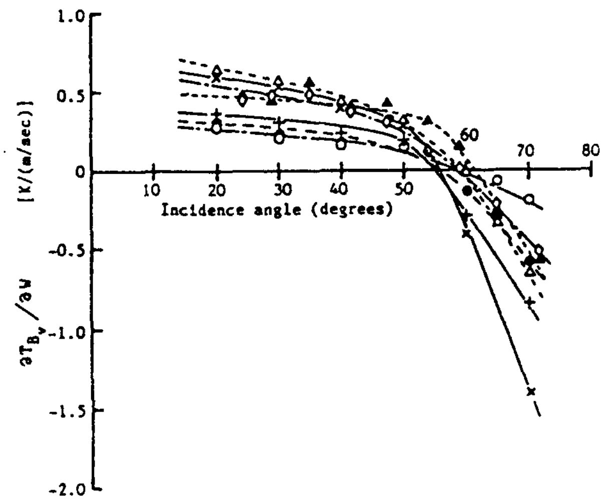


Fig. 3. Dependence of wind speed sensitivity of vertically polarized brightness temperature at different frequencies on incidence angle.

- ○ Hollinger (1.41 GHz)
- ◇ Swift (4.0 GHz)
- + Sasaki *et al.* (6.7 GHz)
- ▲ Swift (7.5 GHz)
- ● Hollinger (8.36 GHz)
- × Sasaki *et al.* (18.6 GHz)
- △ Hollinger (19.34 GHz)

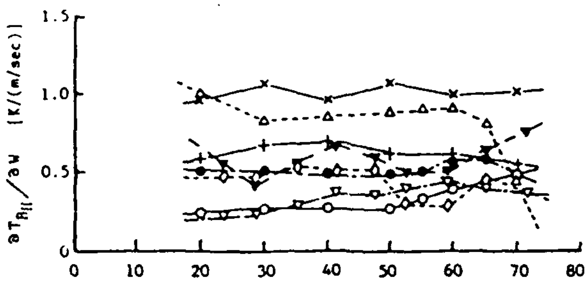
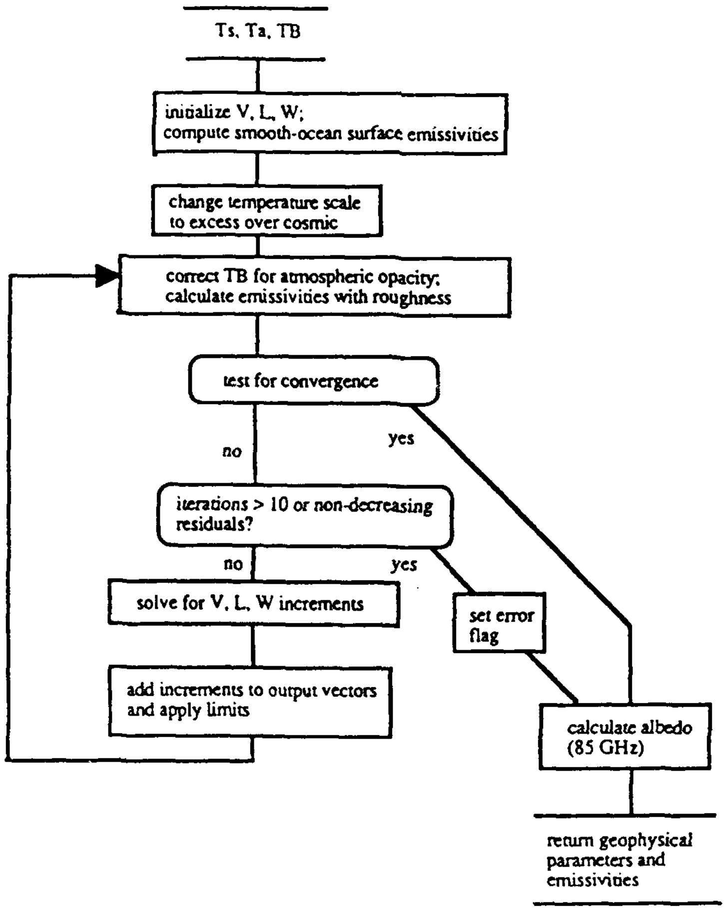
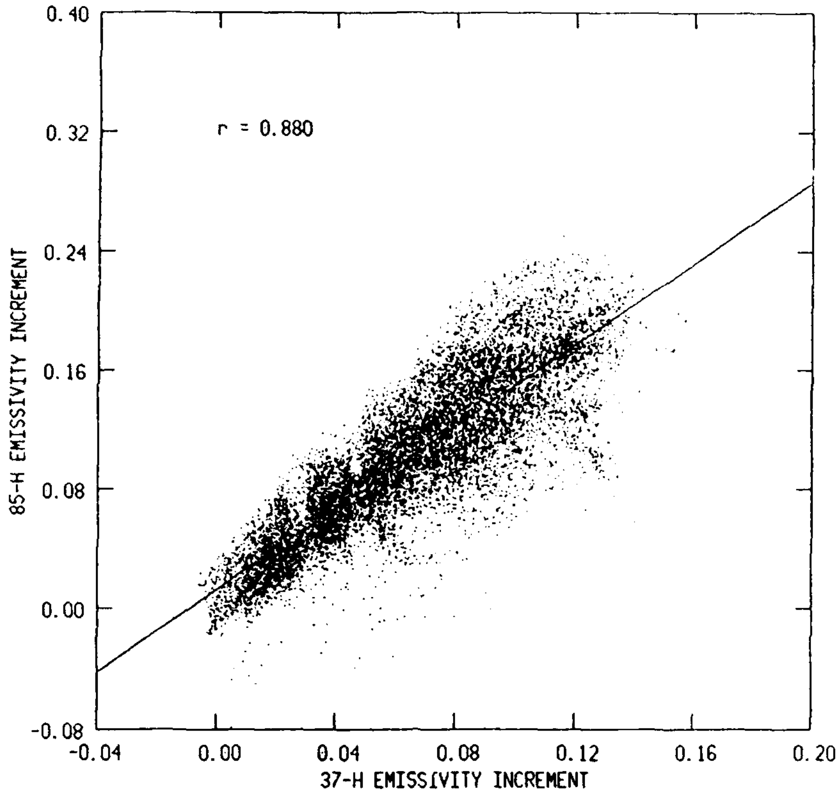


Fig. 4. Dependence of wind speed sensitivity of horizontally polarized brightness temperature at different frequencies on incidence angle.

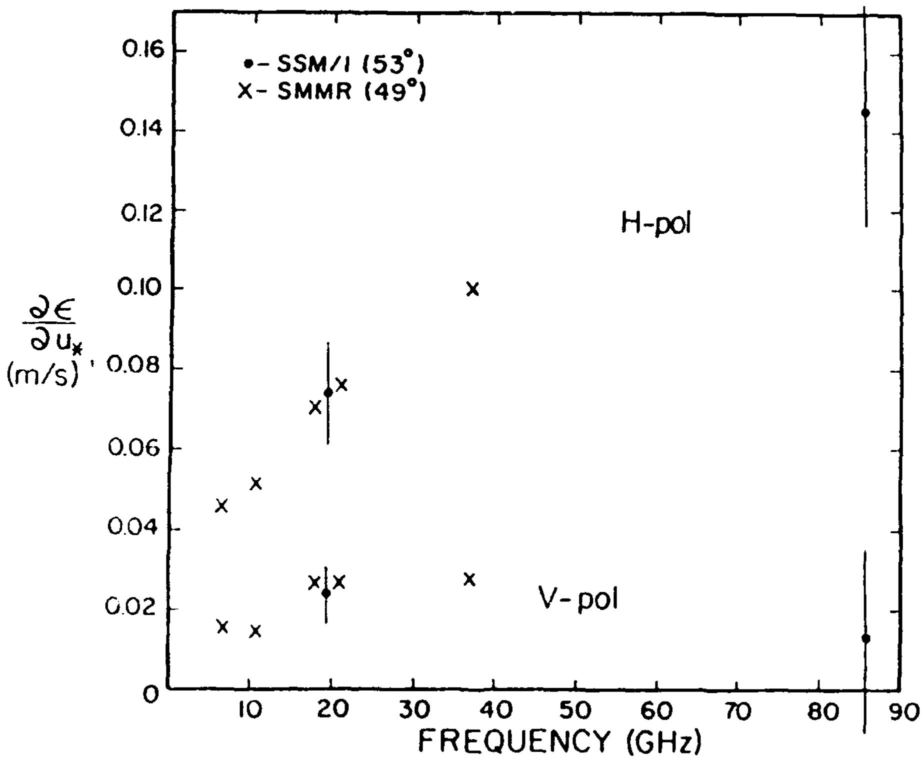
- ○ Hollinger (1.41 GHz)
- ▽ Swift (1.4 GHz)
- ◇ Swift (4.0 GHz)
- \+ Sasaki *et al.* (6.7 GHz)
- ▼ Swift (7.5 GHz)
- ● Hollinger (8.36 GHz)
- × Sasaki *et al.* (18.6 GHz)
- △ Hollinger (19.34 GHz)



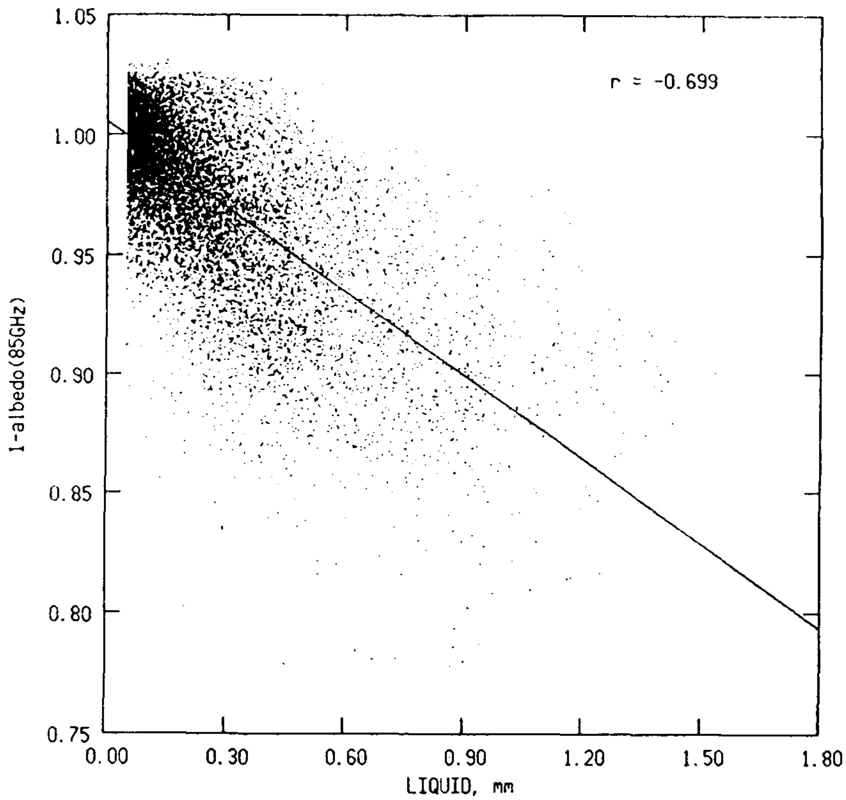
Hydrosphere algorithm.



r = 0.880
85-H EMISSIVITY INCREMENT
37-H EMISSIVITY INCREMENT
0.40
0.32
0.24
0.16
0.08
0.00
-0.08
-0.04
0.00
0.04
0.08
0.12
0.16
0.20



•- SSM/I (53°)
X- SMMR (49°)
H-pol
V-pol
$\frac{\partial \epsilon}{\partial u_*}$ (m/s)
FREQUENCY (GHz)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0
10
20
30
40
50
60
70
80
90

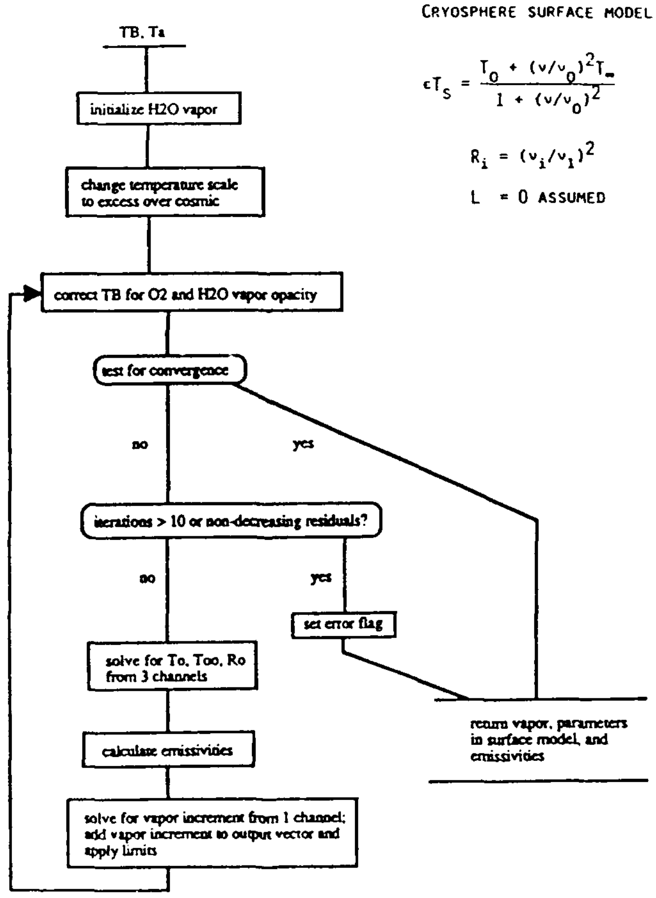


CRYOSPHERE SURFACE MODEL:

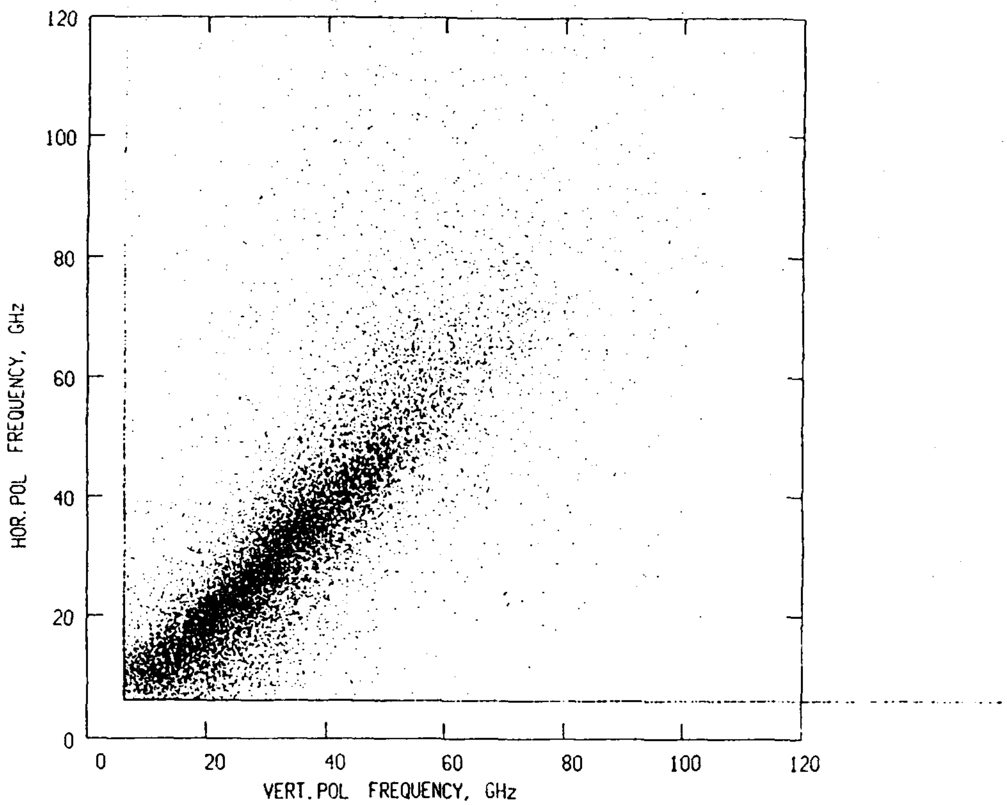
$$\epsilon T_S = \frac{T_0 + (\nu/\nu_0)^2 T_\infty}{1 + (\nu/\nu_0)^2}$$

$$R_i = (\nu_i/\nu_1)^2$$

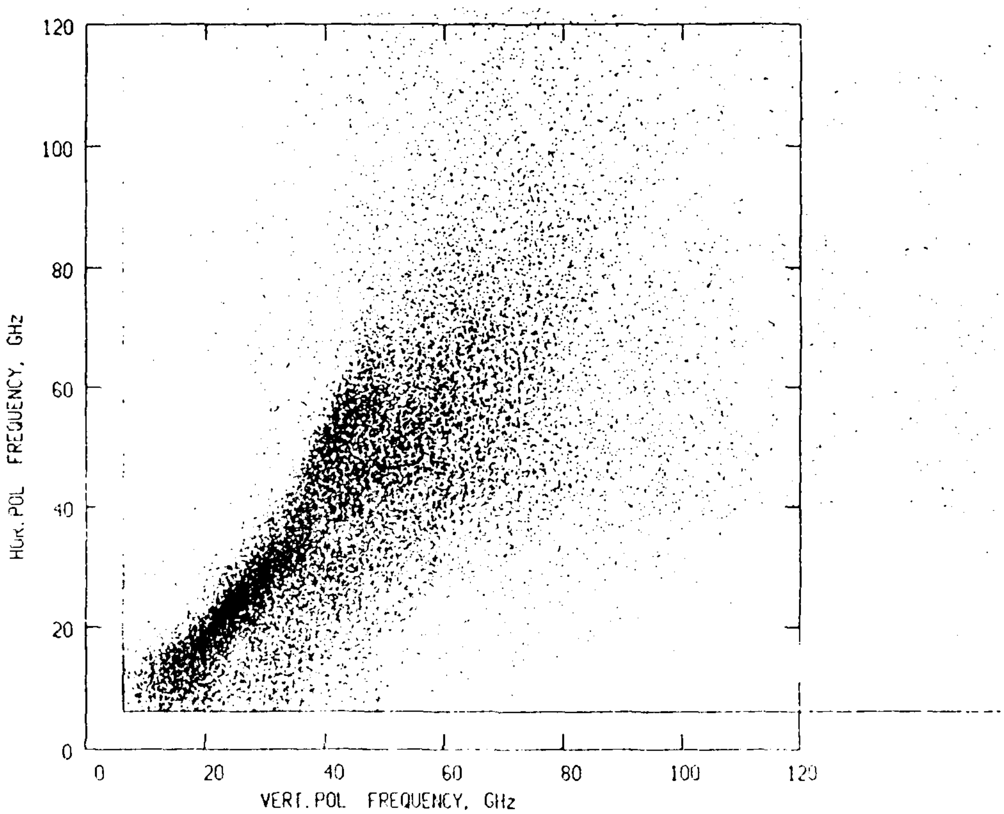
L = 0 ASSUMED



Cryosphere algorithm.



120
100
80
60
40
20
0
HOR. POL FREQUENCY, GHz
0
20
40
60
80
100
120
VERT. POL FREQUENCY, GHz



120
100
80
60
40
20
0
HOR. POL FREQUENCY, GHz
0
20
40
60
80
100
120
VERT. POL FREQUENCY, GHz

Session 4: Applications to Numerical Weather Prediction (Kalnay, chair)

In this session several operational and research atmospheric data assimilation and forecast systems using DMSP products were described. In the last part of the session simple model applications of data to retrieve additional parameters were presented.

The first paper was presented by Pat Phoebus from NOARL. She indicated that the Navy is most advanced in the operational assimilation of DMSP environmental products: SSM/T atmospheric soundings, SSMI surface wind speeds, and water are assimilated in the Navy system. They are also experimenting with the assimilation of SSM/I total precipitable water by creating moisture profiles based on the forecast profiles modified to contain the same total as the SSM/I observation. The present lack of computational resources to make parallel integrations has not allowed a rigorous testing of whether these data have a positive impact upon the forecasts, but indirect evidence suggests that at least the surface wind speeds are beneficial.

Ken Mitchell, from NMC, reviewed the current research on improving the sophistication of the surface parameterizations in the NMC models, which in turn makes them more sensitive to the accurate definition of the current state of surface parameters such as ice and snow cover and soil moisture, as well as cloud cover. He showed that the manually derived NESDIS weekly snow cover analysis, based on AVHRR imagery, is highly reliable, but it becomes obsolete over a few days, so that NMC is exploring the use of a NESDIS experimental snow cover product, based on a SSM/I algorithm developed by N. Grody. Although there are some areas where it underestimates snow cover, it generally looks very promising.

Tsann Yu, from NMC, presented results of experimental assimilations of SSM/I surface wind speeds. Extensive verifications indicated a small but positive impact in the forecasts, as well as a reduction of the data rejected by the Quality Control (QC), indicating better agreement between the 6-hour forecast and the data. It was shown that the use of SSM/I wind speed data produced forecasts which were clearly in better agreement with buoy data, although the analyses were slightly worse. This apparent contradiction was explained by the fact that in the presence of abundant SSM/I additional data, it is much more difficult for the analysis to fit the relatively sparse buoy data. It was also pointed out that SSM/I data near coastal areas should not be included in the "superobs" (1 degree averaged) SSM/I observations. As a result of these encouraging results, NMC plans to make the assimilation of SSM/I wind speeds operational in the near future.

L. Phalippou, from ECMWF, presented comparisons between the SSM/I total precipitable water (TPW) and the ECMWF fields, as a preliminary evaluation of the current ECMWF analysis and its possible use for data QC. Serious discrepancies were found, especially west of the continents over stratus regions and regions of high precipitation. The differences could not be explained by rain contamination upon the SSM/I algorithm, since a correction would increase the discrepancy.

John Derber, from NMC, presented results of an experimental assimilation of SSM/I precipitable water into the NMC analysis system (based on a variational approach denoted Spectral Statistical Interpolation or SSI). He showed that in the tropics, the assimilation of the TPW resulted in an increase in the moisture immediately above the boundary layer (where the model is already close to saturation). As a result, the excess TPW was rained out during the short range forecasts. This discrepancy may be due to problems in the model cumulus parameterization, which may result in too dry a tropical model atmosphere. It could also be due to excessively high TPW estimates from the SSM/I since the retrieved TPW is quite sensitive to the details of the algorithm. For the moment NMC is still experimenting with this data.

Bob Atlas, from NASA/GLA, presented several experiments on the assimilation of SSM/I wind speeds, as well as Seasat and ERS-1 scatterometer winds, and over the horizon (OTH) radars. Although the OTH has several promising features, it also has serious drawbacks. The tests with SSM/I winds showed much better results when the stability of the boundary layer was taken into account in the vertical distribution of observational increments due to SSM/I data.

Andreas Goroch, from NOARL, showed the results of a simple model to describe radiative transfer through a layer of brine over ice. He showed that with the combination of visible, infrared and microwave measurements it should be possible to distinguish between flooded ice, broken ice, and open water regions.

Chris Grassotti, from AES, Canada, presented a model to determine precipitation rates at both short (hourly) and long (monthly) time scales, based on a multispectral statistical classification scheme. The results without using SSM/I data looked promising when compared to VIS/IR data, and SSM/I data will be incorporated in the near future.

Irene Rubenstein, from EOL, Canada, discussed the effect of the influence of evolving cloud hydrometers upon the satellite microwave observations. Results using observations from the Labrador Ice Margin Experiment suggested agreement between the model and observations.

SESSION 4 - APPLICATIONS TO NUMERICAL WEATHER PREDICTION

THE ASSIMILATION OF DMSP RETRIEVAL PRODUCTS INTO THE NAVY'S ATMOSPHERIC PREDICTION SYSTEMS

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The utilization of various DMSP retrieval products by the Navy Operational Global and Regional Atmospheric Prediction Systems (NOGAPS and NORAPS) run at Fleet Numerical Oceanographic Center (FNOC) is described in this paper. DMSP SSM/T temperature soundings are incorporated into both the global and regional prediction systems as layer thicknesses by a multivariate optimum interpolation (MVOI) analysis. The operational assimilation of SSM/I wind speeds into the NOGAPS MVOI analysis was initiated in September 1990. Moisture profiles are produced for inclusion in a global moisture analysis using SSM/I total column precipitable water measurements. The NOGAPS background or first-guess moisture profiles at the location of the SSM/I observations are adjusted so that their total column precipitable water matches what was observed.

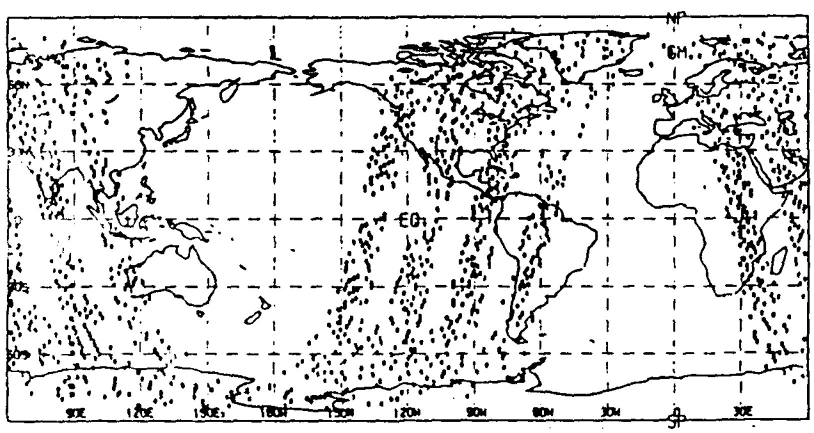
DMSP SATELLITE DATA USE IN NAVY ATMOSPHERIC PREDICTION SYSTEMS

SSM/T temperature soundings from F10 and F11
(NOGAPS and NORAPS)

SSM/I wind speeds from F10 and F11 (NOGAPS)

SSM/I total column precipitable water from
F10 and F11 (to be used by NOGAPS)

DMSP SSM/T SOUNDINGS TYPICAL 6-HOUR COVERAGE



- Mean layer temperatures used to compute layer thicknesses, if necessary.
- Gross-error checks performed on each individual thickness increment.
  - Tolerance T depends on observation error and prediction error.
  - Observation error for DSMP same as for NOAA clear retrievals.
  - Rejection criteria depends on observation location.

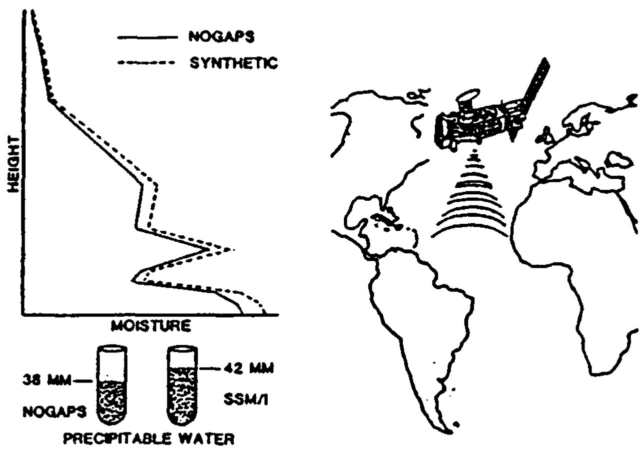
Table 6. Gross-Error Check Thickness Tolerances

T varies with level and data type			
Data Increment Type	*No Checking*	*Further Checking*	*Rejection*
Satellite Thickness			
Polar Areas			
Below 50 mb	$\leq 2.4T$	None	$> 2.4T$
50 to 20 mb	$\leq 3.8T$	None	$> 3.8T$
20 to 10 mb	$\leq 5.8T$	None	$> 5.8T$
Extra-tropics			
Below 50 mb	$\leq 1.5T$	None	$> 1.5T$
50 to 20 mb	$\leq 2.4T$	None	$> 2.4T$
20 to 10 mb	$\leq 3.6T$	None	$> 3.6T$
Tropics			
Below 50 mb	$\leq 1.2T$	None	$> 1.2T$
50 to 20 mb	$\leq 1.9T$	None	$> 1.9T$
20 to 10 mb	$\leq 2.9T$	None	$> 2.9T$

- Lapse-rate checks performed on sounding.
  - Compare to vertical temperature structure of the background field.
    - 1000–700 mb thickness increment compared to 500–300 mb thickness increment.
  - Lowest six layers of the sounding may be rejected (below 300 mb).

GLOBAL MOISTURE ANALYSIS

- DMSP SSM/I Precipitable Water Measurements Are Used to Adjust NOGAPS Moisture Profiles Over Oceans



- Synthetic Profiles Supplement Radiosonde Data Over Land, Resulting In Improved Global Moisture Analysis

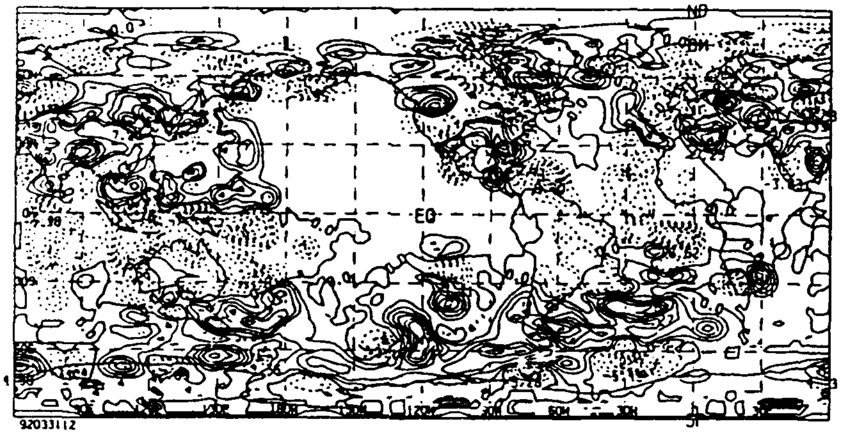
SYNTHETIC MOISTURE PROFILES

Produced at locations of DMSP SSM/I total column precipitable water (PW) measurements

NOGAPS background values of specific humidity are multiplied by the ratio of SSM/I PW to NOGAPS PW [Equivalent to solving variationally using weights proportional to PW in each layer (O'Brien, 1970)]

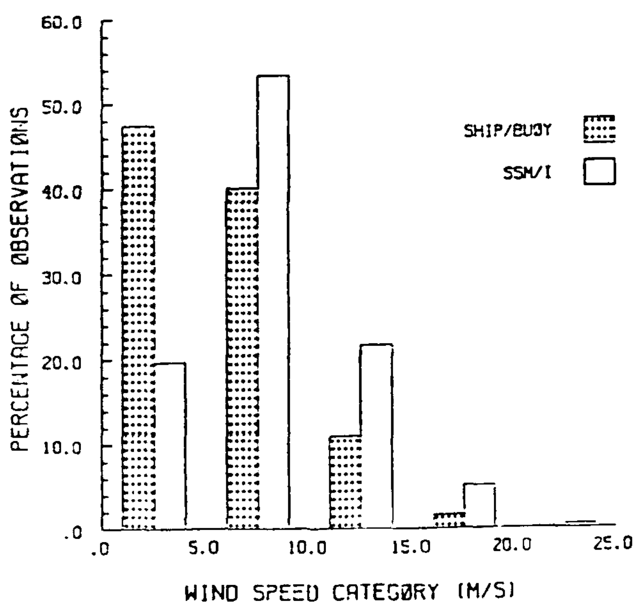
Adjusted values used to create adjusted profiles of dew-point depression for input to moisture analysis

MOISTURE ANALYSIS INCREMENTS
850 MB DEW-POINT DEPRESSION

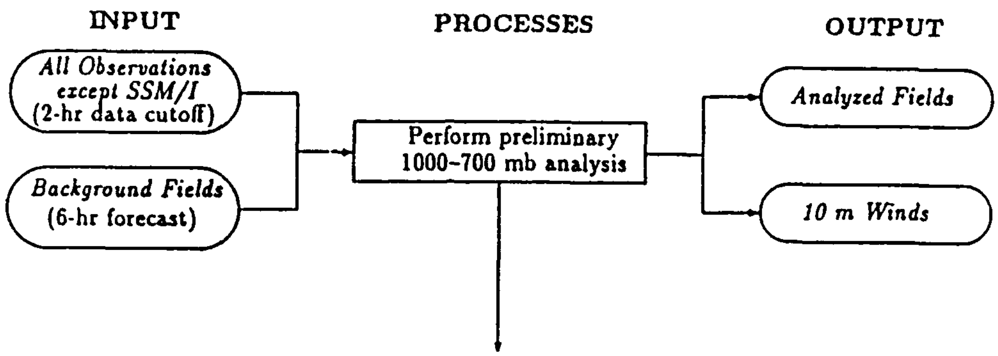


DISTRIBUTION of OBSERVATIONS
by Wind Speed and Data Type

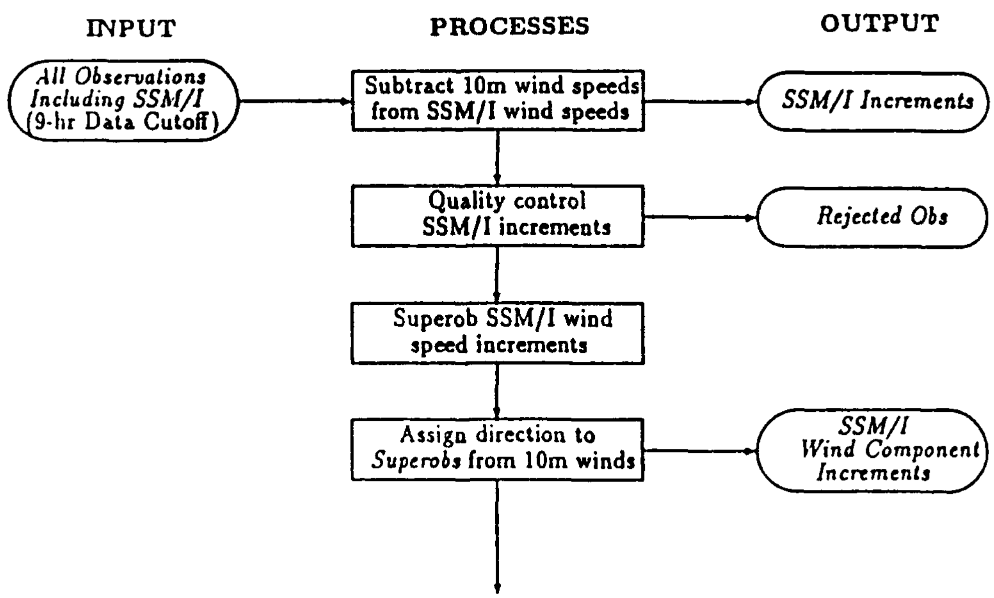
Demonstrates all-weather capability and global coverage of SSM/I.
Ships tend to *avoid* high wind speed areas.



NOGAPS
SSM/I DATA PROCESSING



NOGAPS
SSM/I DATA PROCESSING



SSM/I Quality Control

- Perform preliminary checks prior to analysis.
  - Exclude observations not in rain-free areas.
  - Exclude observations outside the 3–25 m/sec range.
- Compare SSM/I wind speeds to preliminary analysis wind speeds.
  - Reject if background wind is light and SSM/I wind speed is not.
  - Reject if there is a large difference between SSM/I and background.

Preliminary Analysis	*Rejection Criteria*	*Percentage Rejected*
< 4 m s^{-1}	SSM/I > 7 m s^{-1}	$\sim 5.0\%$
4–10 m s^{-1}	$\mid$ Diff $\mid > 7.5$ m s^{-1}	$\sim 1.5\%$
≥ 10 m s^{-1}	$\mid$ Diff $\mid > 10$ m s^{-1}	$\sim 0.1\%$

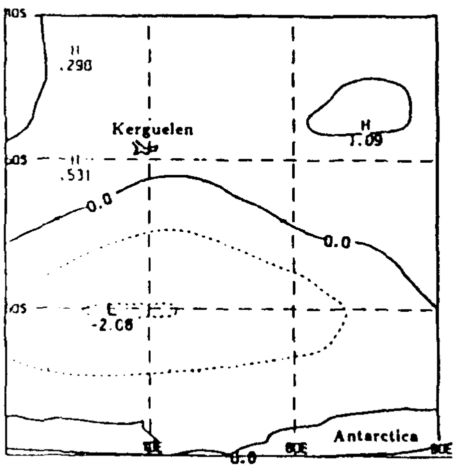
- Compare SSM/I superob wind component increments to surrounding data.
  - Reject if no other supporting data.
  - Very few SSM/I obs are rejected by this test.

NOGAPS Analysis Differences

with SSM/I Winds minus _without_ SSM/I Winds

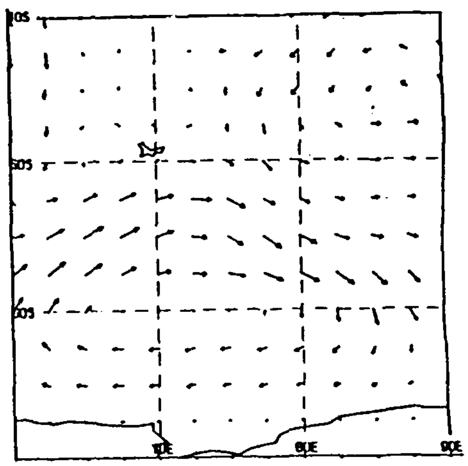
12Z, 17 September 1991

Maximum Difference = 2 mb



Sea-Level Pressure (mb)

Maximum Difference = 10 kts.



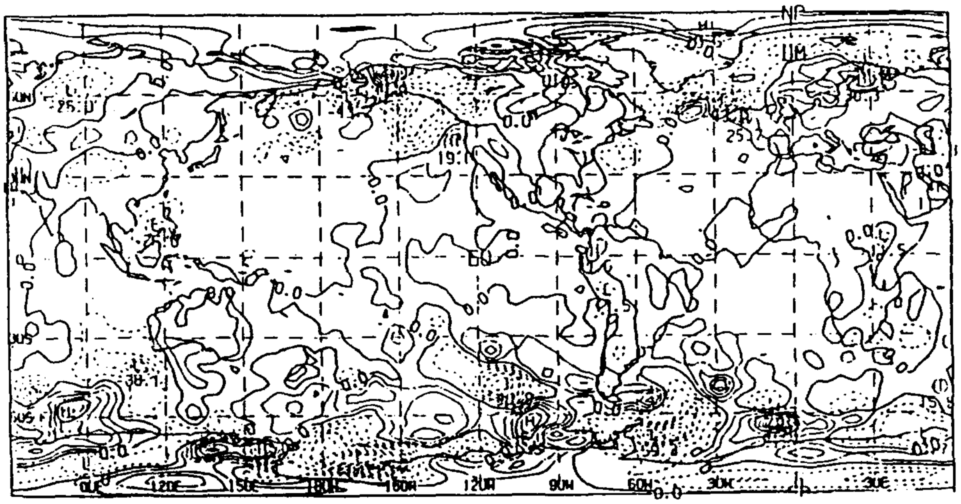
1000 mb Wind (kts)

NOGAPS 48-hr Forecast Differences

***with* SSM/I Winds minus *without* SSM/I Winds**

valid 00Z, 15 March 1991

1000 mb HEIGHT *Maximum Difference = 82 m*



INDEPENDENT DATA COMPARISON

Ship/Buoy Vector RMS Errors

Observation – Background Differences		
RMS	*Before* SSM/I	*After* SSM/I
N Hem	5.0 ms^{-1}	4.9 ms^{-1}
S Hem	5.8 ms^{-1}	5.1 ms^{-1}

- Ship and buoy observations agree more closely with the background wind speeds *after* the SSM/I data have been assimilated.
- Improvement is most pronounced in the Southern Hemisphere.

IMPACT OF SSM/I-BASED SNOW/ICE ANALYSES IN NMC'S ETA *MODEL*

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At various operational numerical weather prediction (NWP) centers, forecast models on global, regional, and meso-scales are incorporating increasingly complex parameterizations of the land/atmosphere interface. These parameterizations require improved specifications of surface conditions, such as snow/ice cover, vegetation, albedo, and soil moisture. Such is the case in the experimental mesoscale forecast model known as the ETA model (so named for its step-mountain eta coordinate) under development at the National Meteorological Center (NMC). The physical parameterizations in the ETA model are described in detail by Janjic (1990).

Following the current practice in NMC's operational Regional Analysis and Forecast System (RAFS), which includes the Nested Grid Model (NGM), experimental runs of the ETA model to date have used a relatively coarse resolution (nominally 2-degree grid) snow/ice analysis produced weekly on Mondays by the Synoptic Analysis Branch (SAB) of NESDIS. This operational NESDIS snow/ice analysis is manually derived on a digitizing table by an analyst who inspects and interprets the most recent cloud-free visible and IR imagery from the AVHRR sensor of NOAA's polar orbiters. This interpretation is complicated in winter by persistent cloud cover at high latitudes and the lack of visible imagery during the arctic night.

The spatial and temporal resolution of the NESDIS operational snow analysis is insufficient for the high resolution specification of snow/ice cover needed by NMC's regional forecast models. The study by Petersen and Hoke (1989) illustrated the detrimental impact of a week-old snow/ice analysis in the RAFS. In their case study, the untimely snow/ice analysis led to poor low-level temperature forecasts and poor delineation of the rain-snow boundary in an area where the snow cover had recently changed.

As an alternative to the weekly analysis of snow/ice cover, NESDIS is producing an experimental, real-time, automated, high-resolution (47 km) snow/ice analysis via retrieval algorithms (Grody, 1991) applied to the Special Sensor Microwave/Imager (SSM/I) instrument aboard the polar orbiters of the Defense Meteorological Satellite Program (DMSP). The SSM/I has a conical scan with a swath width of 1400 km. At the middle and high latitudes associated with snow/ice cover, the areas scanned by consecutive orbits of the SSM/I give total hemispheric coverage in less than 24 hours (i.e. daily coverage). In addition, the SSM/I retrieval of snow/ice is not contaminated by cloud cover or precipitation, nor does it require sunlight.

In this study, we illustrate the impact of replacing the weekly, 2-degree, operational NESDIS snow/ice analysis with the latter "daily" 47-km, experimental SSM/I snow/ice analysis as input to the surface specification for experimental mesoscale runs of NMC's ETA model on a 30-km grid. We focus on cases of recent significant changes in snow-cover being missed in the operational analysis due to the weekly update frequency. The errors in snowcover in turn produce nontrivial errors in surface heat fluxes (owing to snowcover induced errors in the surface albedo and skin temperature), and hence errors in the low-level ETA model temperature forecasts. These low-level temperature errors in turn lead to errors in the inferred rain/snow boundary. We will show that both types of errors can be avoided in the ETA model by alternatively using the timely specification of snow/ice cover afforded by the SSM/I retrieval.

References:

Janjic, Z.I., 1990: The step-mountain coordinates: physical package. *Mon. Wea. Rev.*, 118: 1427-1443.

Petersen, R.A., and J.E. Hoke, 1989: The effect of snow cover on the Regional Analysis and Forecast System (RAFS) low-level forecasts. Wea. and Forecasting, 4: 253-257.

Grody, N.C., 1991: Classification of Snow Cover and Precipitation Using the Special Sensor Microwave Imager. *J. Geophys. Res.*, 96, 7423-7435.

IMPACT OF SSM/I-BASED SNOW/ICE ANALYSES IN THE NMC ETA MODEL

OR

COMPARISONS OF SSM/I SNOW/ICE RETRIEVALS WITH NESDIS AND USAF OPERATIONAL SNOW/ICE ANALYSES

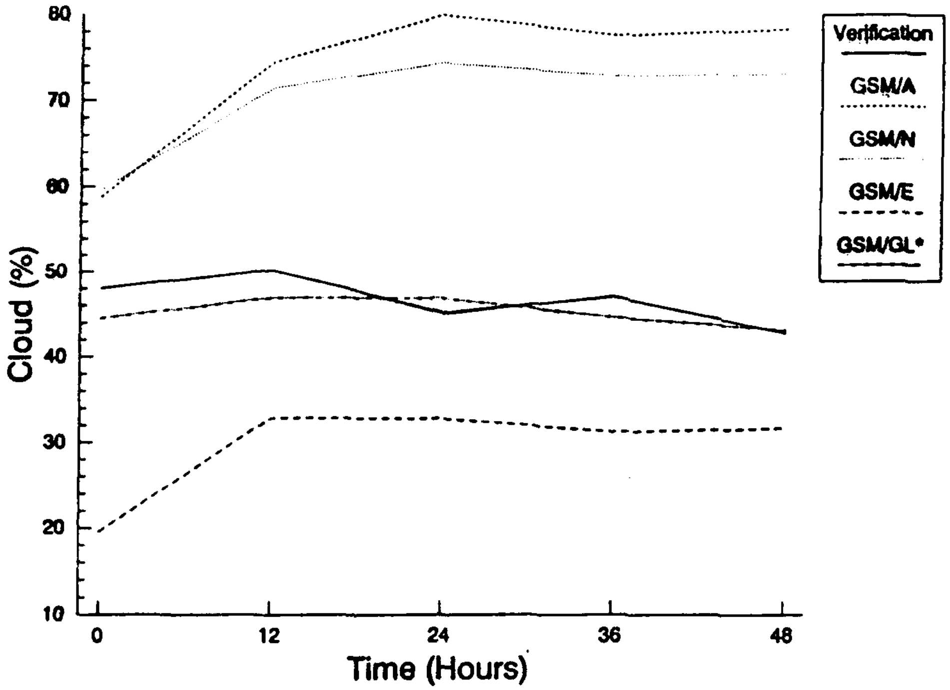
KEN MITCHELL (NMC),
J. PEREIRA (USAF), M. PECNICK (CENTEL),
C. BOETTCHER (SMSRC), N. GRODY (NESDIS)

NMC/NESDIS/DOD DMSP CONFERENCE
APRIL 14-15, 1992

DMSP PRODUCTS
(NWP PERSPECTIVE)

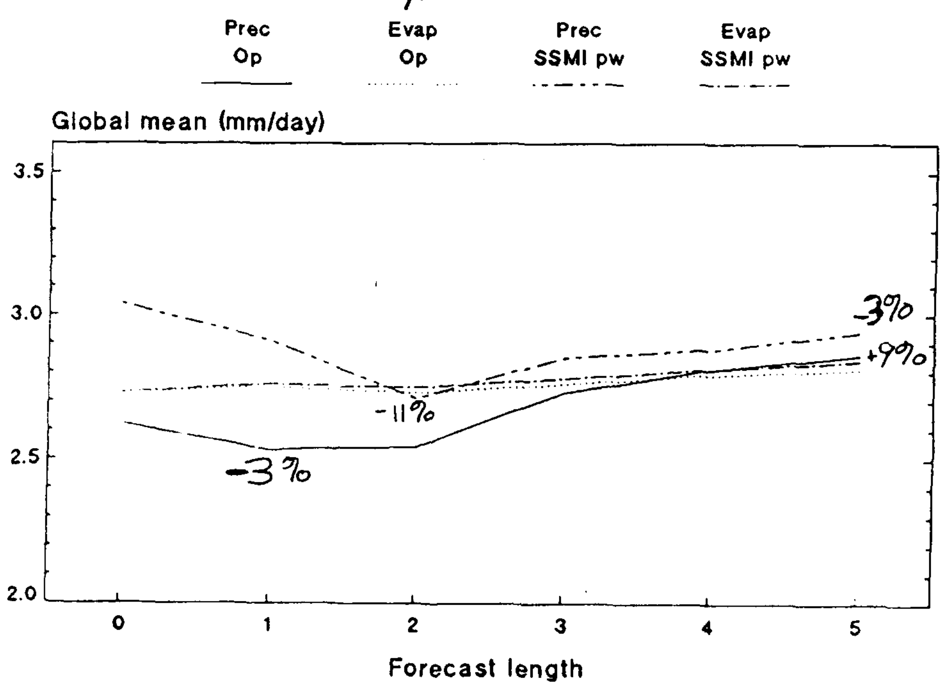
- **SSM/T-1 (NESDIS)**
  - Temperature profiles
- **SSM/T-2 (NESDIS)**
  - Water vapor profiles
- **SSM/I (FNOC/NRL)**
  - Ocean surface wind speed
  - Ocean column water vapor
  - Snow/Ice
  - Rain rates
- **OLS (AFGWC)**
  - RTNEPH cloud analysis
    - -- NWP cloud forecast schemes
    - -- rain rate estimates (AGROMET)
    - -- access via NESDIS/SPN

N.H. Octagon Mean Cloud Amount



Global Mean Water Balance

3/10-24



NMC 2001 VISION

1. **A NATIONAL MESOSCALE MODEL**

   - ULTIMATELY ON 4 KM GRID

2. **UNLIKELY THAT OBSERVATIONAL DATA WILL PROVIDE A COMPLETE DESCRIPTION OF THE INITIAL CONDITIONS ON SUCH A FINE GRID**

3. **SCIENTIFIC BASIS ON WHICH OUR HIGH RESOLUTION MESOSCALE EXPECTATIONS REST IS THE CONCEPT THAT MOST MESOSCALE CIRCULATIONS ARE DRIVEN BY INTERACTIONS OF LARGE SCALE WITH LOWER BOUNDARY**

   - DETAILED TOPOGRAPHY
   - SURFACE HEAT AND MOISTURE FLUXES
     -- LAND (Soil wet., Vegetation, Snow, Albedo, Z0)
     -- SEA (SST's, Sea Ice)
     -- CLOUD COVER

ETA MODEL SUMMARY

PHYSICS: (JANJIC, MWR, 1990)

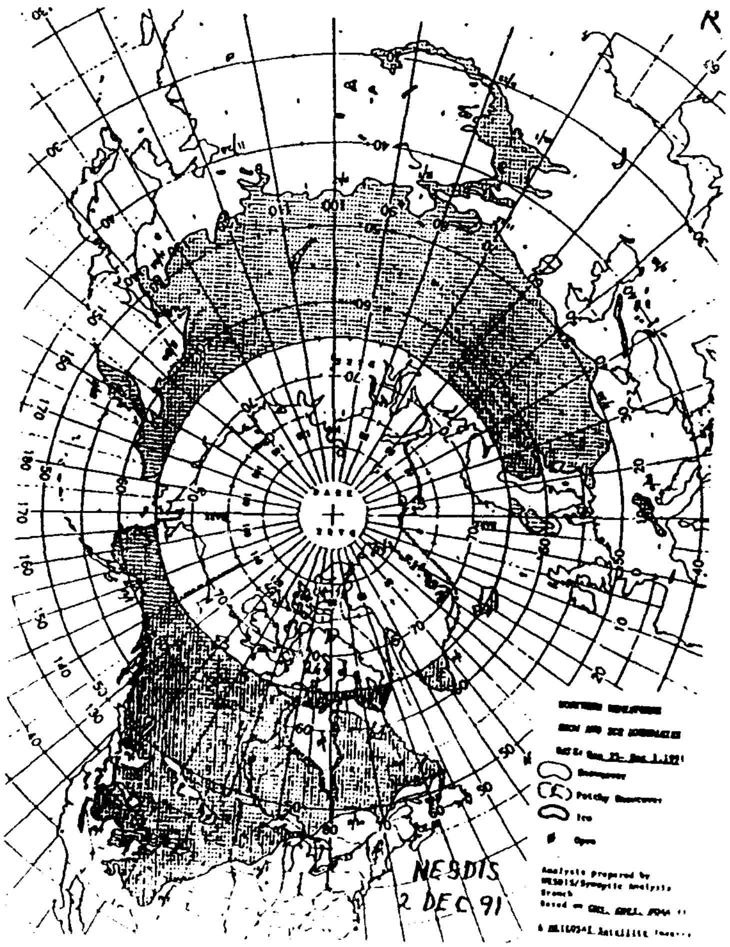
- BETTS/MILLER CONVECTION
- GFDL RADIATION
- MELLOR/YAMADA 2.5 PBL
- FORCE/RESTORE SLAB SFC

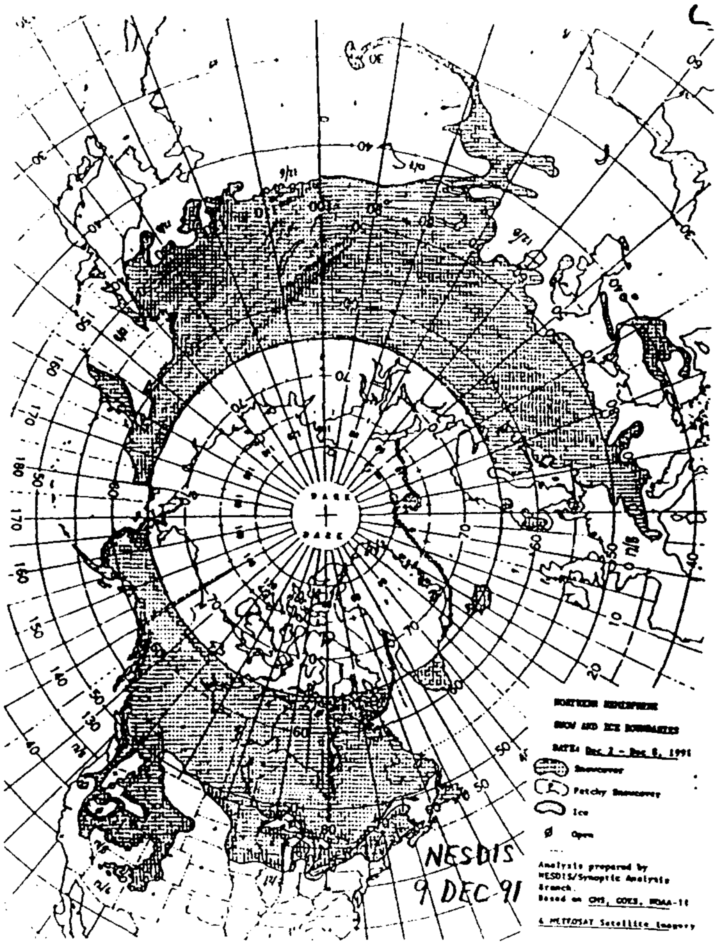
$$\frac{\partial Tg}{\partial t} = \underset{1\ \ 2}{(1-A)S\downarrow} + \underset{2}{L\downarrow} + L\uparrow + H + \underset{3-4}{MA*Ep} + \underset{4}{G} + \underset{5}{SNW}$$

1 - ALBEDO
2 - CLOUDS
3 - VEGETATION
4 - SFC/SOIL MOISTURE
5 - SNOW/ICE COVER

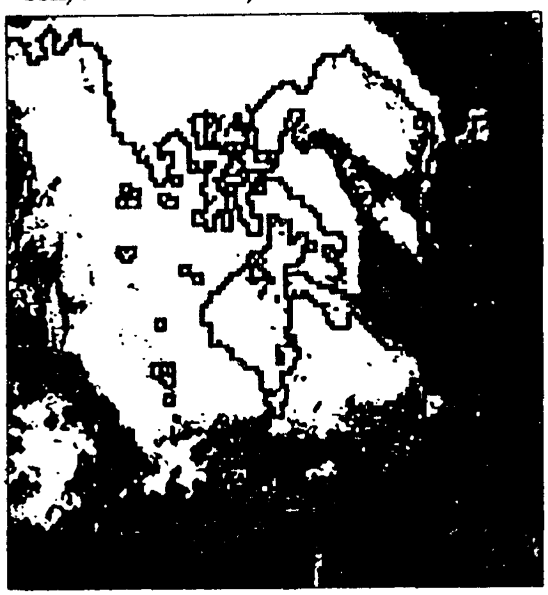
SNOW ANALYSIS CHARACTERISTICS

	NESDIS	SSM/I	USAF
Timeliness	WEEKLY	DAILY	DAILY
Resolution	190 km	23 km	46 km
Analyst	YES	NO	YES
Stations	NO	NO	YES
Ice Flag	NO	YES	YES
Reliability	GOOD	FAIR	GOOD
Cloud Mask	YES	NO	YES



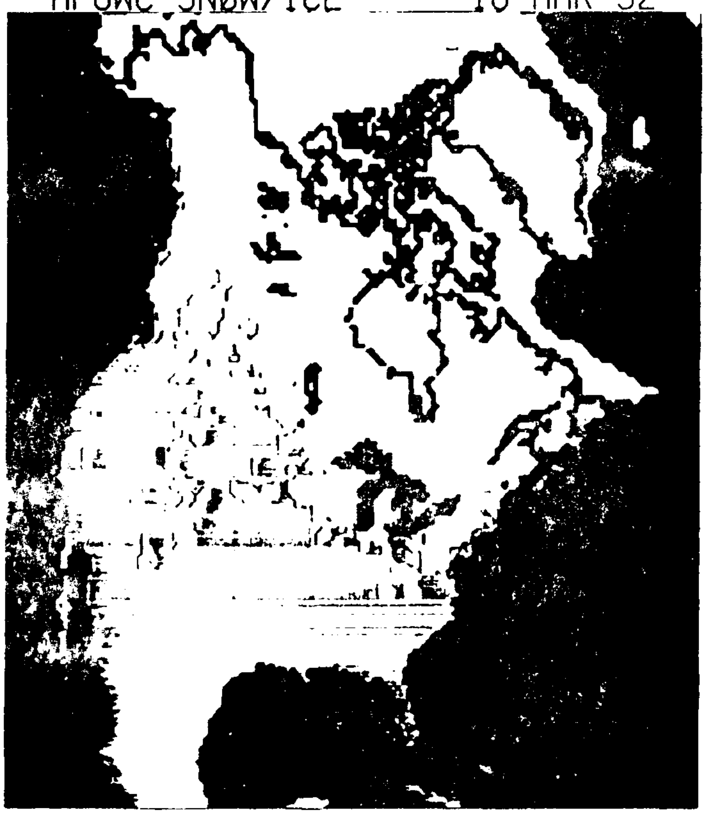


SSM/I F-10 SNOW/ICE -- 9 DEC 1991

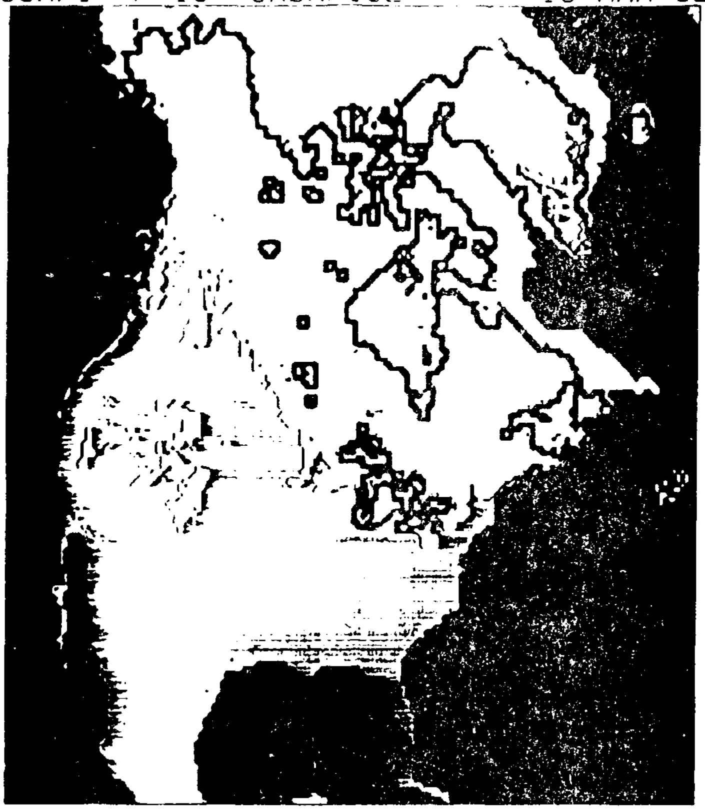


NESDIS SAB SNØW/ICE 16 MAR 92

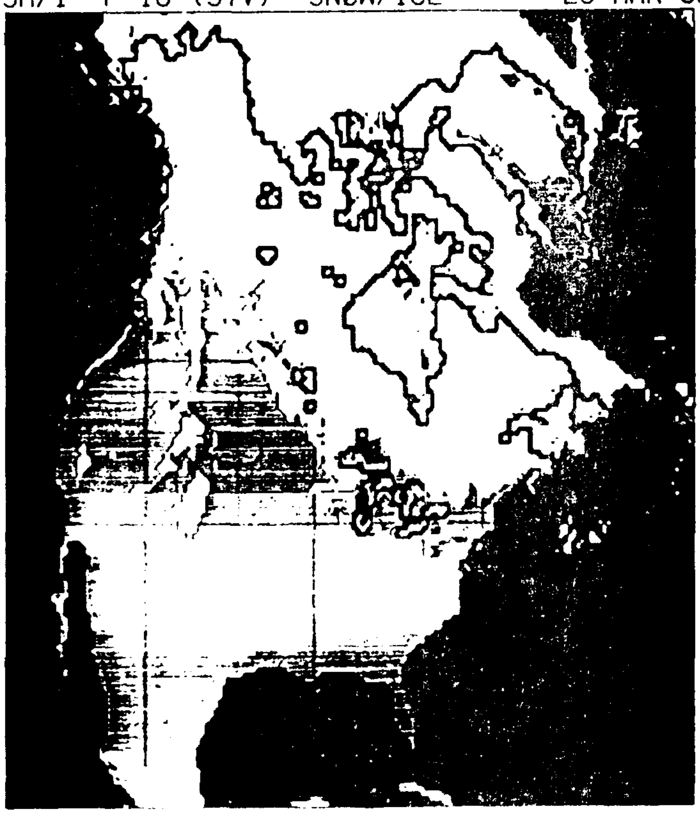
AFGWC SNØW/ICE -- 16 MAR 92



SSM/I F-10 SNØW/ICE -- 16 MAR 92

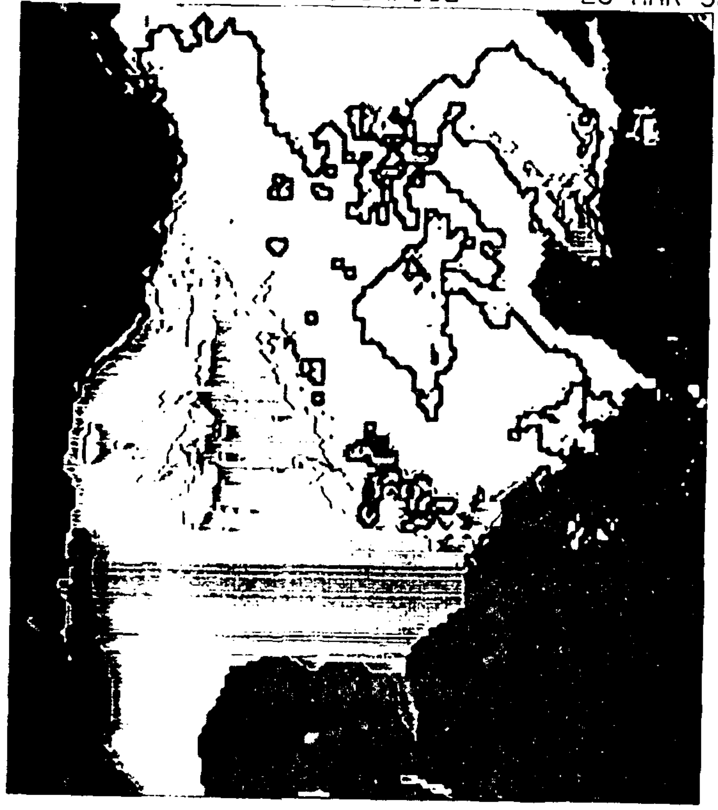


SSM/I F-10 (37V) SNØW/ICE -- 23 MAR 92



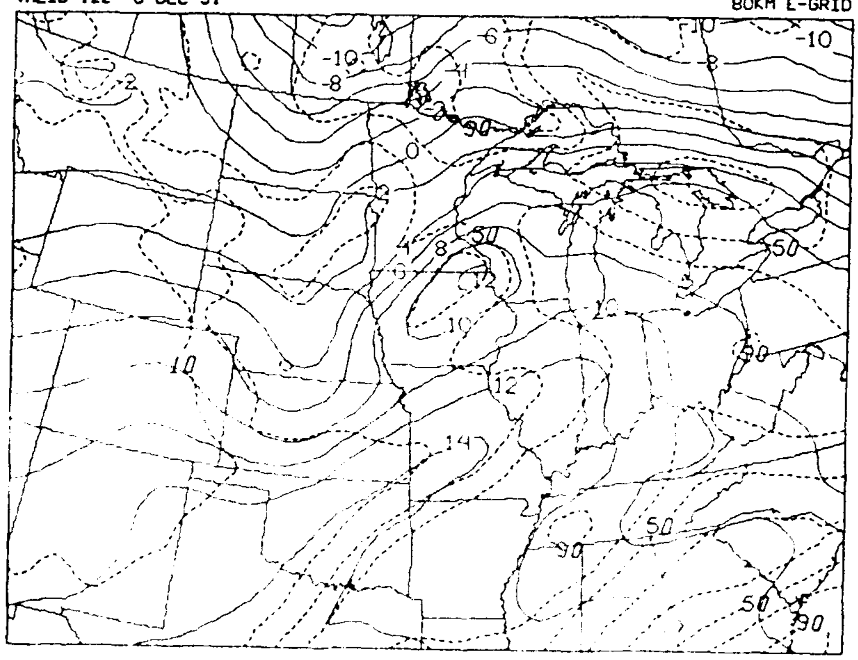
"OPERATIONAL"

SSM/I F-10 ([redacted]) SNØW/ICE -- 23 MAR 92



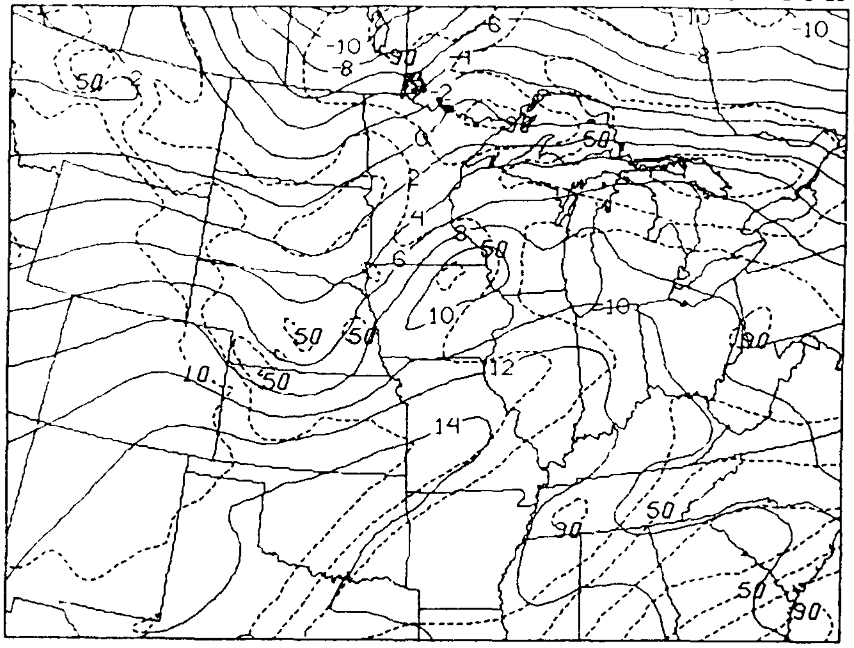
850 MB TEMPERATURE (C)
850 MB REL HUMIDITY (%)
VALID 12Z 8 DEC 91

24-H ETA FCST
80KM E-GRID



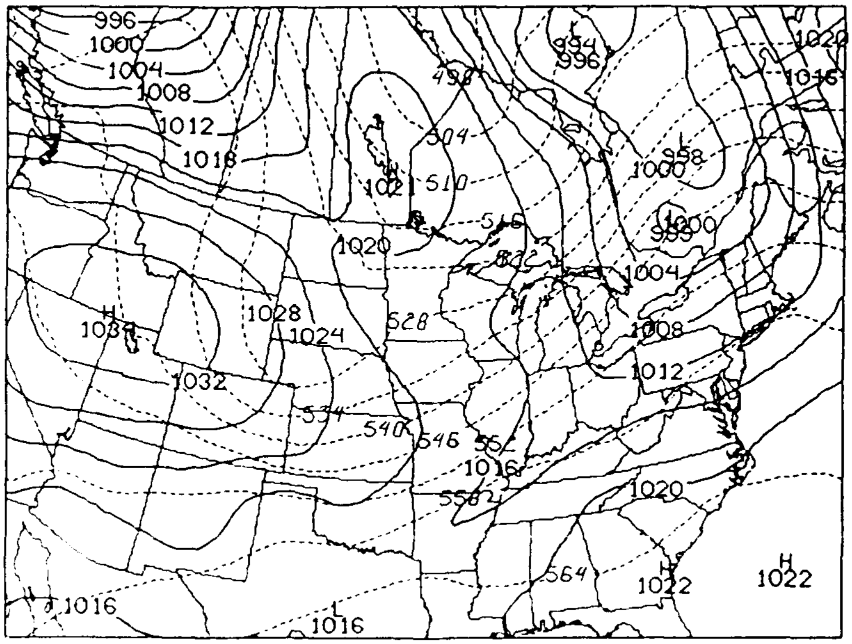
850 MB TEMPERATURE (C)
850 MB REL HUMIDITY (%)
VALID 12Z 8 DEC 91

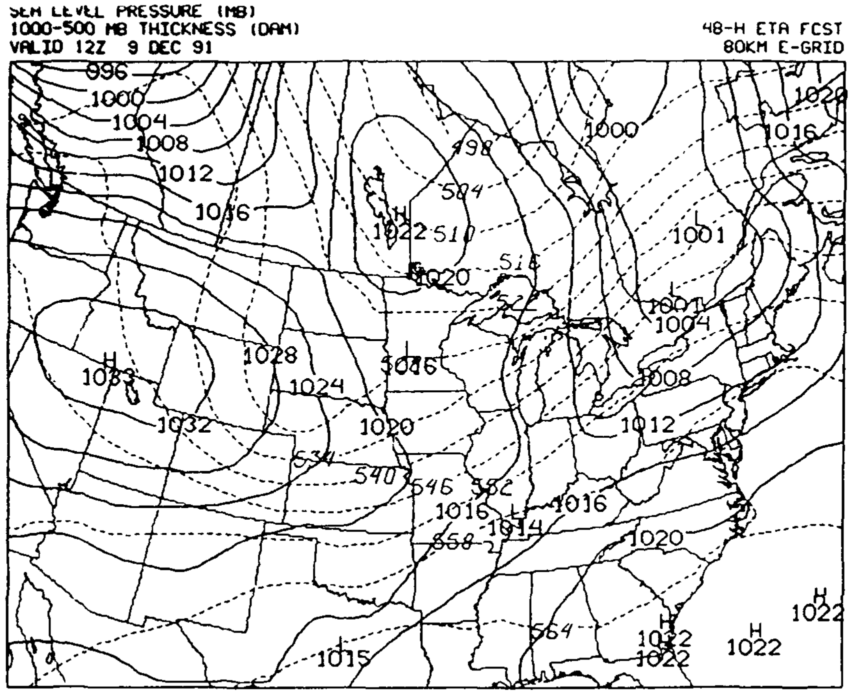
24-H ETA FCST
80KM E-GRID



1000-500 MB THICKNESS (DAM)
VALID 12Z 9 DEC 91

48-H ETA FCST
80KM E-GRID





NESDIS/GRODY SNOW RETRIEVAL CONSIDERED IMPROVEMENTS

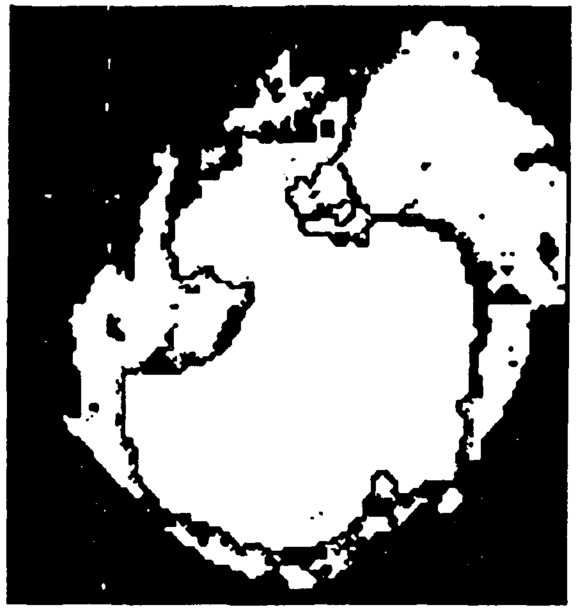
1 - SPACECRAFT SPECIFIC COEFFICIENTS

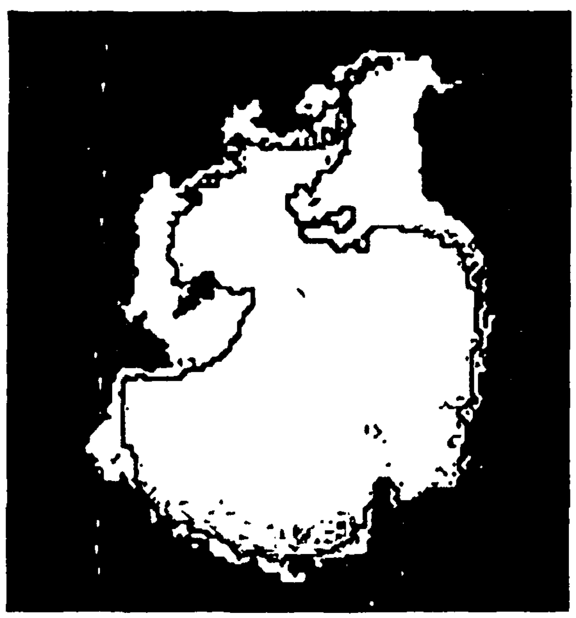
2 - MAP SPATIALLY AVERAGED FOOTPRINTS

3 - THRESHOLD TUNING

4 - MERGED F-10 AND F-11 MASTER MAP

5 - RESOLVE ASCENDING VS DESCENDING PRODUCT DIFFERENCES





CONCLUSIONS

1) WEEKLY NESDIS OPERATIONAL SNOW/ICE ANAL IS TOO CRUDE FOR ETA MESOSCALE FCSTS

2) NESDIS SSM/I SNOW/ICE RETRIEVAL NOT RELIABLE
   -- Misses large areas of snow
   -- False ice ribbons along coasts
   -- Lacks retrieval over coastal points

3) USAF SNOW/ICE ANALYSIS BY ITSELF WILL BE SOURCE OF FIRST PARALLEL TESTS

4) FOR THE FUTURE, A BLEND OF USAF AND SSM/I ANALYSES MAY BE SUPERIOR
   -- Requires improved retrieval algorithm

5) URGE AFGWC TO USE SSM/I SNOW/ICE PRODUCT AS A SUBJECTIVE INPUT TO USAF SNOW/ICE ANAL

USE OF SSM/I WIND SPEED DATA IN THE OPERATIONAL NUMERICAL WEATHER PREDICTION SYSTEM AT NMC

T.W. Yu, W.H. Gemmill, and J. Woollen

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National Meteorological Center
Washington, DC 20233

The Special Sensor Microwave Imager (SSM/I) system on board the U.S. DMSP satellite is capable of measuring global ocean surface wind speeds, among other things, and these wind speed data are now routinely available at the National Meteorological Center (NMC). However, the SSM/I wind speed data do not include wind directions, and therefore additional provisions have to be included in the NMC's operational analysis system to handle the wind data. A procedure for assigning wind directions to the SSM/I wind speed data for use in the operational global data assimilation system has been designed and tested. Several data quality control procedures specially designed for the operational use of the SSM/I wind speed data have been developed, which are being discussed in a separate paper. Results of analyses and forecasts based on the use of the SSM/I wind data for an extended period in the NMC's operational assimilation and forecast system will be discussed. These results are compared with those of the analyses and forecasts which do not include the SSM/I wind data to assess the impact of the data on the operational numerical weather prediction.

Use of SSM/I Wind Speed Data in the Operational Numerical Weather Prediction System at NMC

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National Meteorological Center
National Weather Service, NOAA
Washington D.C., 20233

Use of SSM/I Wind Data in NMC's GDAS

- Five-days Data Assimilation and Forecast Experiments
  (April 4, 00Z 1991 → April 8, 12Z, 1991)
  OI analysis with NLNMI, T80
- Three-weeks Data Assimilation and Forecast Experiments
  (Nov 25, 00Z → Dec 13, 00Z 1991)
  T62 SSI analysis
- One-month Data Assimilation & FCST.
  (Dec 24, 00Z 1991 → Jan 29, 12Z, 1992)
  T126 SSI analysis

The Assimilation System

Forecast Model : Spectral T80 resolution
18 σ layers

Analysis scheme : Optimum Interpolation on
1° x 1° longitude - latitude grids
σ layers directly
with a stability dependent vertical
structure function in O/I

Initialization : Non-linear Normal Mode
Initialization

Summary of Assimilation and
Forecast Experiments

Exp.1	W/o SSM/I Wind, Constant Function
Exp.2	W/o SSM/I Winds, Variable Function
Exp.3	With SSM/I Winds, Constant Function
Exp.4	With SSM/I Winds, Variable Function

Assimilation Period : 4/4/00z – 4/8/18z, 1991
FCST Exps : 4/8/00z/1991 Initial Conditions

DiMego (MWR, 1988)

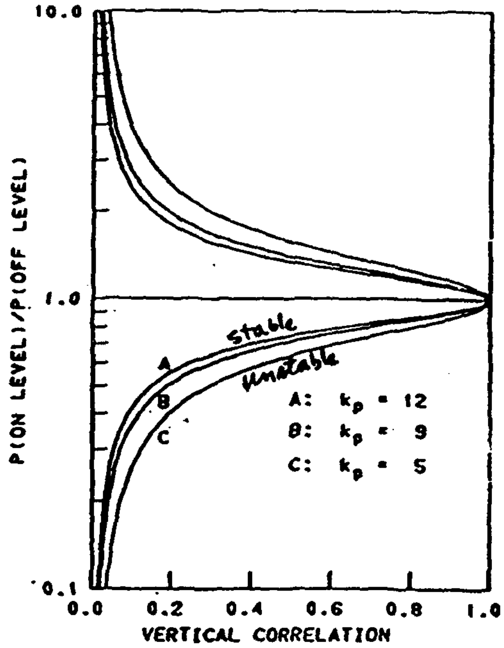


FIG. 5. Variation of the vertical correlation factor given by Eq. (6) with coefficient k_p.

$$r_{k_i k_j} = \frac{1}{1 + k_p \ln^2(P_i/P_j)}, \qquad (6)$$

$K_p = f(\text{stability})$

RMS Differences (FG - Radiosondes)

valid at 4/8/00z/1991

	1000 mb Z	1000 mb VW	500 mb Z	500 mb VW
Northern Hemisphere				
Exp. 1	17.3	4.3	23.4	6.9
Exp. 2	16.8	4.3	23.8	6.9
Exp. 3	14.4	4.2	22.8	6.8
→ Exp. 4	14.3	4.0	23.0	6.7
Southern Hemisphere				
Exp. 1	12.5	4.9	53.3	7.5
Exp. 2	12.5	5.1	52.8	7.3
Exp. 3	11.8	4.6	51.5	7.0
→ Exp. 4	11.5	4.5	50.6	6.9

RMS Differences (FG - Radiosondes)

Exp 4 With SSM/I Winds, Variable Function

Assimilation Period	N. H. 1000 mb Z	N. H. 1000 mb VW	N. H. 500 mb Z	N. H. 500 mb VW	S. H. 1000 mb Z	S. H. 1000 mb VW	S. H. 500 mb Z	S. H. 500 mb VW
4/6/00Z	16.4	4.7	21.6	8.6	21.5	14.7	25.2	6.9
4/7/00Z	14.1	4.5	21.4	8.4	13.2	6.3	18.7	9.3
4/8/00Z	14.3	4.0	23.0	6.7	11.5	4.5	50.6	6.9

RMS Differences (F24 - Radiosonde)

	1000 mb Z	1000 mb VW	500 mb Z	500 mb VW
N. H.				
Exp. 1	23.2	6.0	30.7	7.7
Exp. 2	22.4	5.9	30.1	7.5
Exp. 3	23.0	6.0	31.1	7.7
→ Exp. 4	22.0	5.8	29.7	7.3
S. H.				
Exp. 1	17.4	5.2	34.9	6.7
Exp. 2	13.8	4.9	29.8	6.1
Exp. 3	17.5	5.2	33.9	6.8
→ Exp. 4	12.3	4.8	30.0	5.8

PRV (with SSM/I Winds)

number of [redacted] rejected by ob type. and zone (NOV 29, 00Z)

OBS TYPE	90°S – 60°S	60°S – 30°S	30°S – 0°	0° – 30°N	30°N – 60°N	60°N – 90°N
80	0.0	0.0	3.0	21.0	44.0	0.0
81	1.0	0.0	35.0	66.0	219.0	9.0
83	0.0	0.0	0.0	3.0	4.0	4.0
90	0.0	0.0	0.0	0.0	0.0	0.0
~~120~~	[illegible]	[illegible]	[illegible]	~~29.0~~	~~82.0~~	~~16.0~~
130	0.0	0.0	1.0	17.0	14.0	0.0
132	0.0	0.0	0.0	0.0	0.0	0.0
133	0.0	0.0	0.0	1.0	4.0	0.0
161	22.0	18.0	144.0	1318.0	918.0	727.0
162	4.0	5.0	34.0	334.0	324.0	144.0
163	12.0	18.0	4.0	287.0	731.0	492.0
171	15.0	193.0	455.0	2580.0	460.0	1060.0
172	4.0	113.0	107.0	1130.0	390.0	140.0
173	29.0	248.0	97.0	430.0	850.0	330.0
~~180~~	[illegible]	[illegible]	[illegible]	~~28.0~~	~~50.0~~	~~3.0~~
181	1.0	7.0	38.0	60.0	225.0	29.0
183	0.0	0.0	0.0	2.0	26.0	6.0
~~220~~	[illegible]	[illegible]	[illegible]	~~36.0~~	~~48.0~~	~~29.0~~
221	0.0	0.0	7.0	3.0	0.0	0.0
230	1.0	0.0	1.0	3.0	29.0	0.0
232	0.0	0.0	0.0	2.0	0.0	0.0
233	0.0	0.0	0.0	0.0	6.0	0.0
240	0.0	1.0	0.0	0.0	0.0	0.0
242	0.0	0.0	0.0	0.0	0.0	0.0
243	0.0	0.0	0.0	0.0	0.0	0.0
250	0.0	0.0	0.0	0.0	0.0	0.0
252	0.0	0.0	0.0	0.0	0.0	0.0
253	0.0	0.0	0.0	0.0	0.0	0.0
~~280~~	[illegible]	[illegible]	[illegible]	3.0	25.0	0.0
282	0.0	0.0	0.0	0.0	0.0	0.0
283	0.0	0.0	0.0	0.0	0.0	0.0

120 Radiosonde T 180 Ship T
220 Radiosonde Wind 280 Ship Wind

PRZ (OPERATIONAL)

number of obs rejected by ob type. and zone (Nov 29, 00Z)

OBS TYPE	90°S – 60°S	60°S – 30°S	30°S – 0	0° – 30°N	30°N – 60°N	60°N – 90°N
80	0.0	0.0	3.0	25.0	40.0	0.0
81	1.0	3.0	38.0	63.0	215.0	10.0
83	0.0	0.0	0.0	10.0	14.0	3.0
90	0.0	0.0	0.0	0.0	0.0	0.0
120	0.0	10.0	19.0	31.0	103.0	19.0
130	0.0	0.0	1.0	16.0	14.0	0.0
132	0.0	0.0	0.0	0.0	0.0	0.0
133	0.0	0.0	0.0	1.0	7.0	0.0
161	11.0	20.0	139.0	1337.0	904.0	764.0
162	1.0	4.0	34.0	334.0	361.0	162.0
163	11.0	18.0	3.0	278.0	789.0	492.0
171	36.0	213.0	466.0	2560.0	480.0	1070.0
172	4.0	115.0	109.0	1120.0	410.0	140.0
173	27.0	251.0	91.0	450.0	870.0	330.0
180	0.0	5.0	9.0	32.0	51.0	5.0
181	1.0	8.0	49.0	65.0	234.0	31.0
183	0.0	0.0	0.0	2.0	25.0	7.0
220	8.0	12.0	8.0	41.0	52.0	32.0
221	0.0	0.0	5.0	3.0	1.0	0.0
230	1.0	0.0	1.0	3.0	30.0	0.0
232	0.0	0.0	0.0	2.0	0.0	0.0
233	0.0	0.0	0.0	0.0	6.0	0.0
240	0.0	1.0	0.0	0.0	0.0	0.0
242	0.0	0.0	0.0	0.0	0.0	0.0
243	0.0	0.0	0.0	0.0	0.0	0.0
250	0.0	0.0	0.0	0.0	0.0	0.0
252	0.0	0.0	0.0	0.0	0.0	0.0
253	0.0	0.0	0.0	0.0	0.0	0.0
280	0.0	1.0	0.0	5.0	2.0	[illegible]
282	0.0	0.0	0.0	0.0	0.0	0.0

PRX (with SSM/I Winds)

number of obs rejected by ob type. and zone(JAN 15, 00Z)

OBS TYPE	90°S - 60°S	60°S - 30°S	30°S - 0°	0° - 30°N	30°N - 60°N	60°N - 90°N
80	0.0	0.0	3.0	18.0	31.0	2.0
81	3.0	1.0	29.0	48.0	163.0	4.0
83	0.0	0.0	0.0	4.0	39.0	1.0
90	0.0	0.0	0.0	0.0	0.0	0.0
91	0.0	0.0	0.0	0.0	0.0	0.0
120	0.0	2.0	27.0	47.0	119.0	21.0
130	0.0	23.0	14.0	23.0	26.0	0.0
131	0.0	0.0	0.0	0.0	0.0	0.0
133	0.0	0.0	0.0	7.0	17.0	0.0
161	5.0	14.0	56.0	1043.0	697.0	367.0
162	0.0	4.0	11.0	137.0	183.0	27.0
163	5.0	9.0	2.0	167.0	708.0	381.0
171	9.0	69.0	311.0	1630.0	170.0	595.0
172	6.0	43.0	61.0	460.0	30.0	10.0
173	8.0	81.0	51.0	280.0	340.0	270.0
180	0.0	5.0	14.0	37.0	39.0	2.0
181	1.0	6.0	47.0	66.0	262.0	31.0
183	0.0	0.0	0.0	6.0	28.0	4.0
220	5.0	1.0	17.0	24.0	59.0	30.0
221	0.0	3.0	11.0	17.0	1.0	0.0
230	0.0	3.0	0.0	7.0	31.0	2.0
231	0.0	0.0	0.0	0.0	0.0	0.0
233	0.0	0.0	0.0	0.0	12.0	0.0
240	0.0	0.0	0.0	0.0	0.0	0.0
242	0.0	0.0	0.0	1.0	0.0	0.0
243	0.0	0.0	0.0	0.0	0.0	0.0
250	0.0	0.0	0.0	0.0	0.0	0.0
252	0.0	0.0	0.0	0.0	0.0	0.0
253	0.0	0.0	0.0	0.0	0.0	0.0
280	0.0	0.0	0.0	3.0	6.0	0.0
282	0.0	0.0	0.0	0.0	0.0	0.0
283	0.0	0.0	0.0	1.0	0.0	0.0

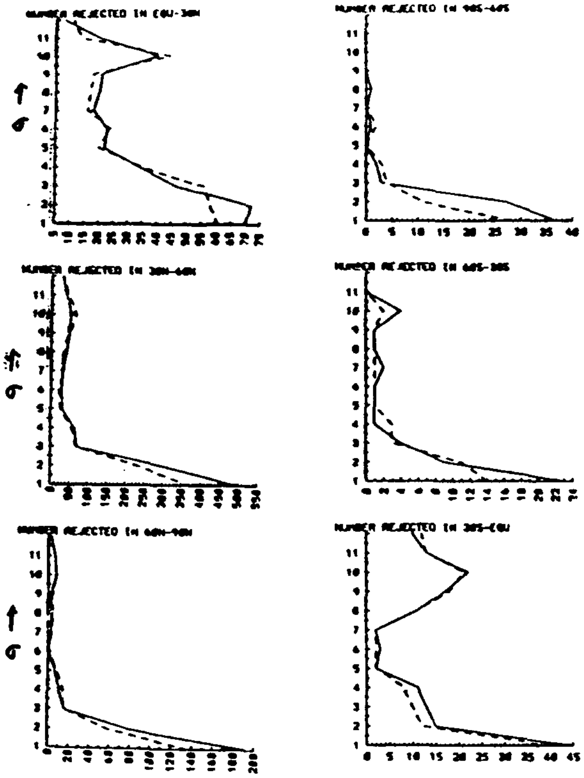
OBS TYPE 120 Radiosonde Temp 180 Ship Temp
220 Radiosonde Wind 280 ship wind

PRZ (OPNL)

number of obs rejected by ob type. and zone(JAN 15, 00Z)

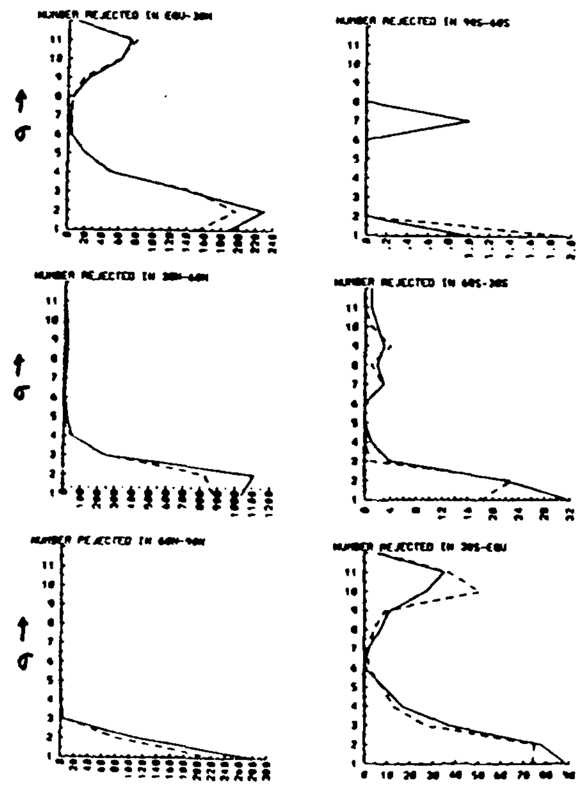
OBS TYPE	90°S - 60°S	60°S - 30°S	30°S - 0°	0° - 30°N	30°N - 60°N	60°N - 90°N
80	0.0	0.0	3.0	19.0	24.0	2.0
81	2.0	1.0	33.0	49.0	164.0	5.0
83	0.0	0.0	0.0	5.0	45.0	2.0
90	0.0	0.0	0.0	0.0	0.0	0.0
91	1.0	0.0	0.0	0.0	0.0	0.0
120	0.0	4.0	26.0	63.0	135.0	25.0
130	0.0	23.0	25.0	24.0	27.0	0.0
131	0.0	0.0	0.0	0.0	0.0	0.0
133	0.0	0.0	0.0	7.0	16.0	0.0
161	5.0	17.0	71.0	1108.0	725.0	395.0
162	2.0	7.0	14.0	154.0	183.0	27.0
163	3.0	7.0	8.0	194.0	738.0	355.0
171	13.0	58.0	374.0	1610.0	180.0	620.0
172	7.0	46.0	69.0	470.0	30.0	10.0
173	5.0	81.0	60.0	310.0	370.0	260.0
180	0.0	4.0	16.0	42.0	41.0	1.0
181	1.0	6.0	49.0	65.0	279.0	28.0
183	0.0	0.0	0.0	4.0	30.0	4.0
220	6.0	1.0	16.0	22.0	75.0	43.0
221	0.0	5.0	8.0	19.0	1.0	0.0
230	0.0	3.0	0.0	6.0	30.0	3.0
231	0.0	0.0	0.0	0.0	0.0	0.0
233	0.0	0.0	0.0	0.0	12.0	0.0
240	0.0	0.0	0.0	0.0	0.0	0.0
242	0.0	0.0	0.0	1.0	0.0	0.0
243	0.0	0.0	0.0	0.0	0.0	0.0
250	0.0	0.0	0.0	0.0	0.0	0.0
252	0.0	0.0	0.0	0.0	0.0	0.0
253	0.0	0.0	0.0	0.0	0.0	0.0
280	0.0	1.0	0.0	4.0	3.0	0.0
282	0.0	0.0	0.0	0.0	0.0	0.0

RADIOSONDE WINDS (Dec 24 '91 – Jan 10 '92)



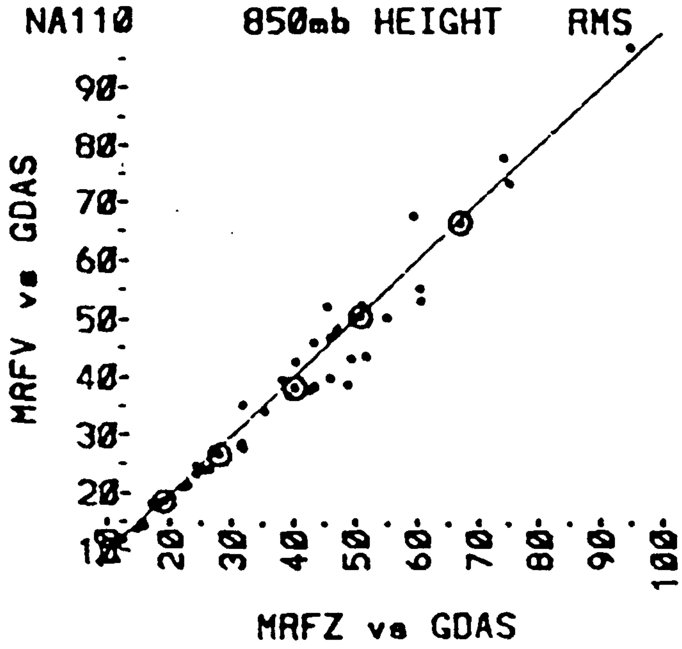
——— CONTROL ------ (Exp with SSM/I)

RADIOSONDE TEMPERATURES (Dec 24 '91 – Jan 10 '92)

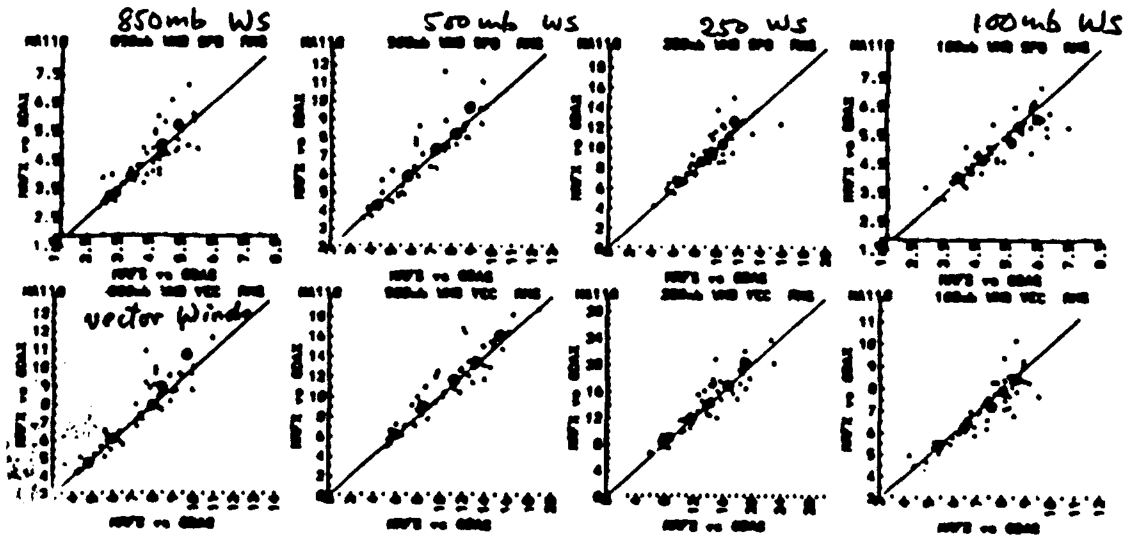


——— control ------ (Exp with SSM/I)

SUMACS
FCST ERRORS

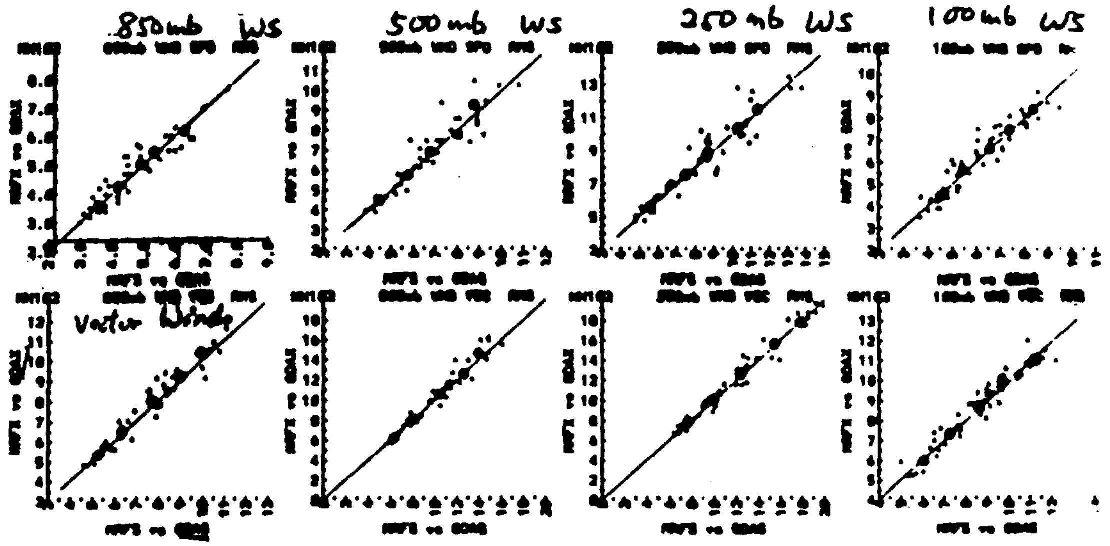


T126 (Dec 24, 91-JAN 4'92)



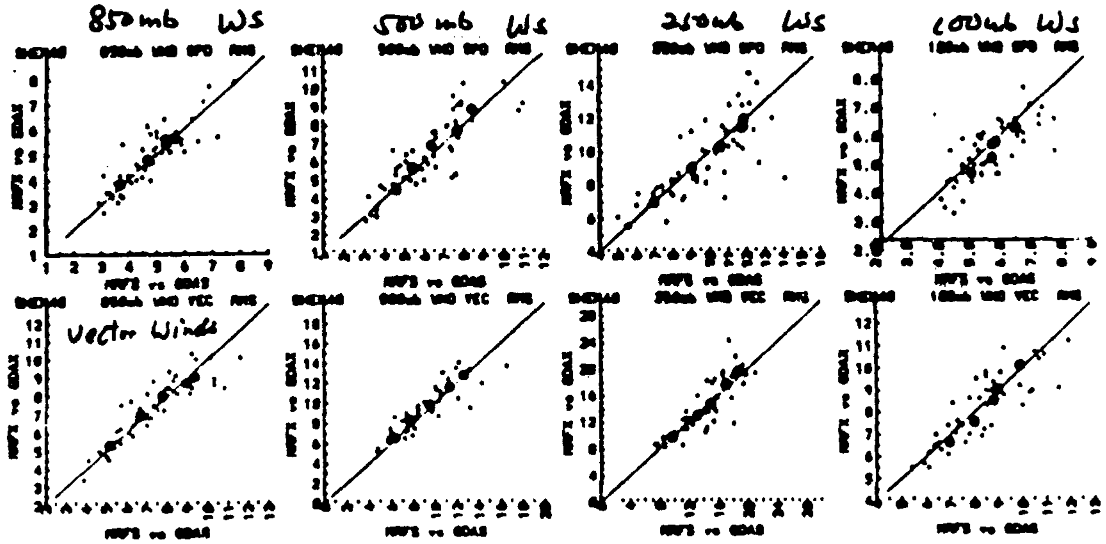
N. America FCST ERRORS

T126 (Dec 24, 91 - Jan 4 '92)



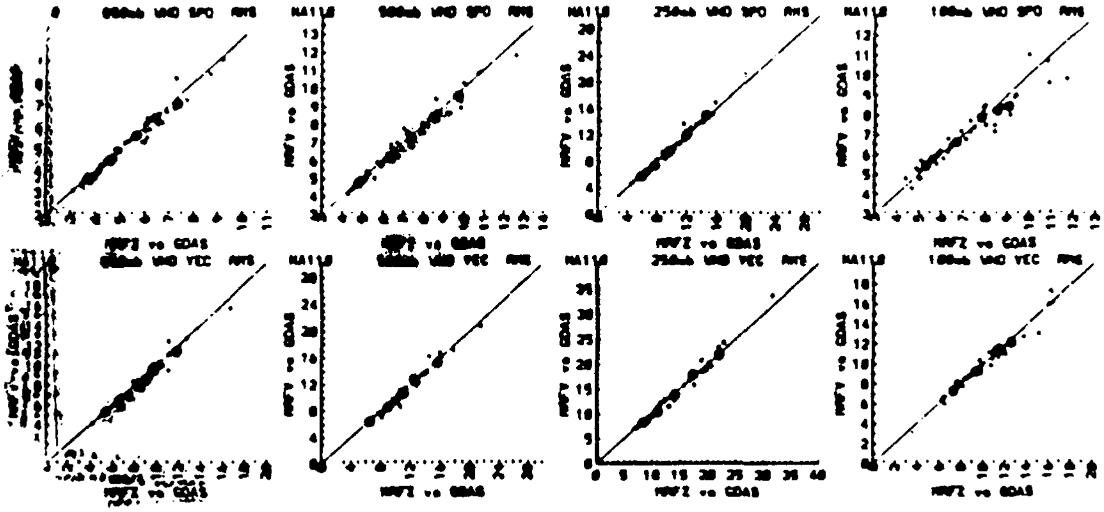
N. HEMISPHERE FCST errors

T126 (Dec 24, 91 - JAN 4 '92)



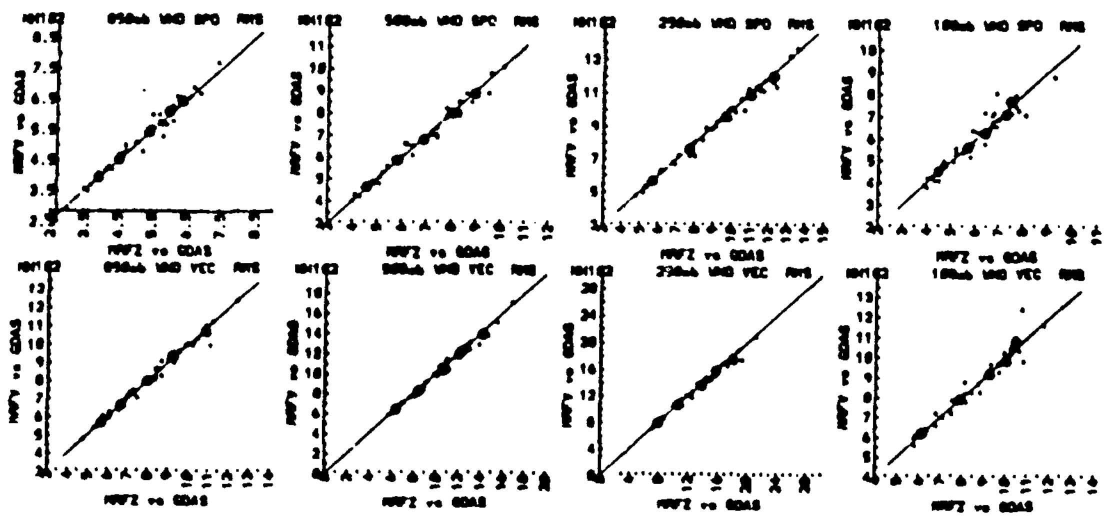
S. HEMISPHERE FCST errors

T62 (11/25/91-12/13/91)



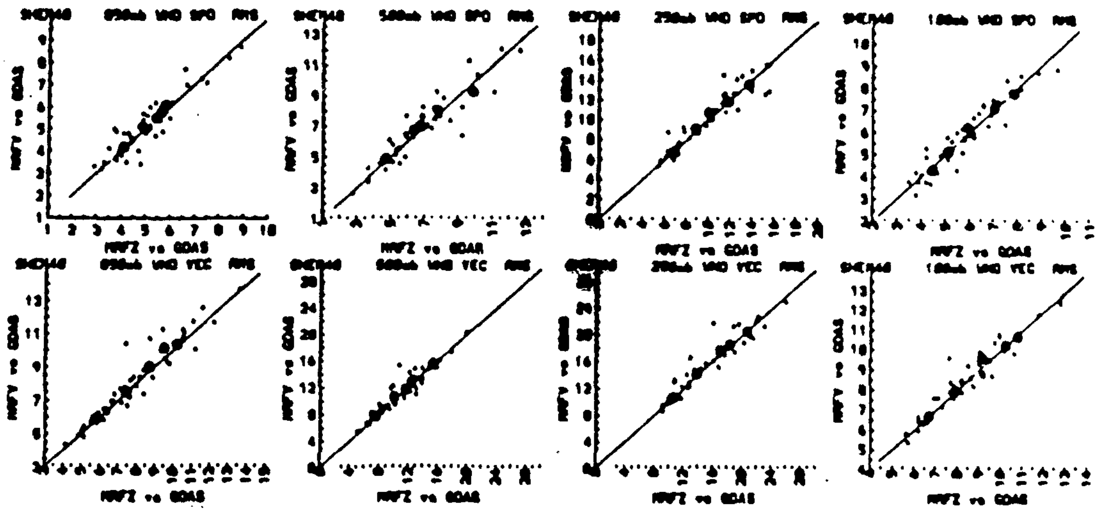
N. America

T62 (11/25/91-12/13/91)



N. Hemisphere

T62 (11/25/91 – 12/13/91)



S. Hemisphere

COMPARISON BETWEEN SSM/I AND ECMWF TOTAL PRECIPITABLE WATER

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Shinfield Park
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The atmospheric parameters which can be retrieved from data from the Special Sensor Microwave/Imager (SSM/I) on the DMSP satellites include the total precipitable water (TPW), cloud liquid water (CLW) and surface marine wind speed. These three parameters are of importance for numerical weather prediction (NWP). This paper presents the first results of a comparison between the SSM/I-TPW and the ECMWF model humidity field. SSM/I data have been acquired in the WetNet/McIDAS context for the July to September 1987 period. The goal of this comparison is to identify possible weaknesses of the ECMWF humidity analysis and to control the quality of SSM/I products.

WATER VAPOUR FROM SSM/I DATA

COMPARISON WITH ECMWF ANALYZED HUMIDITY FIELDS

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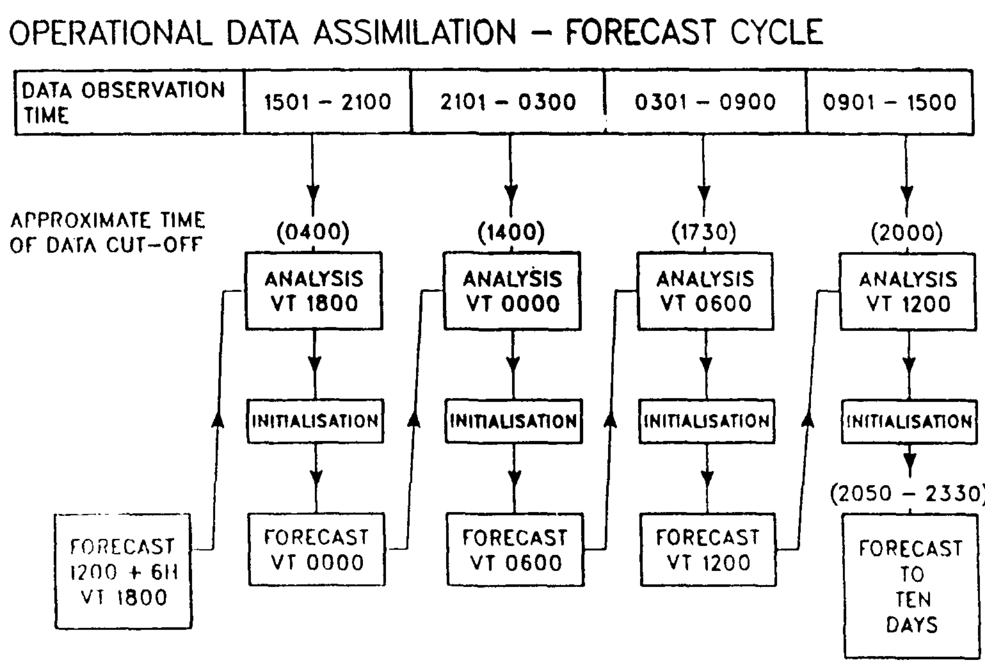
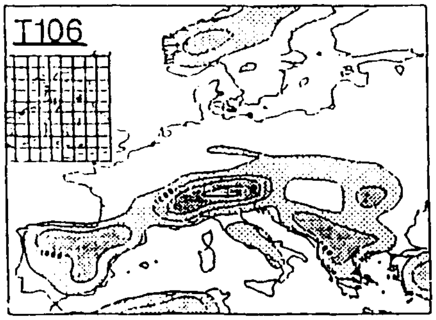
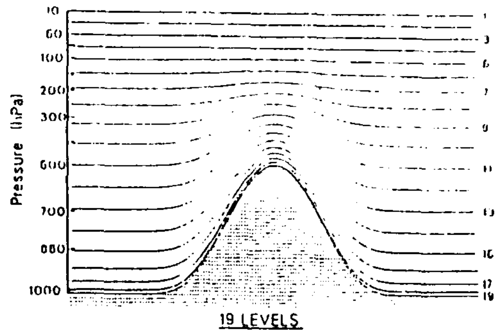
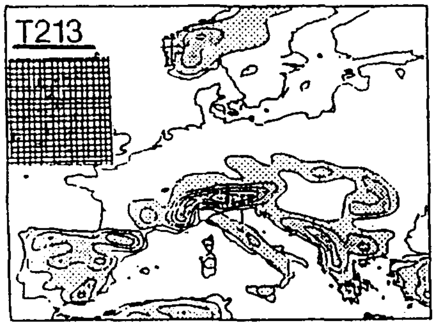
Email LaurentPhalippou@ecmwf.co.uk



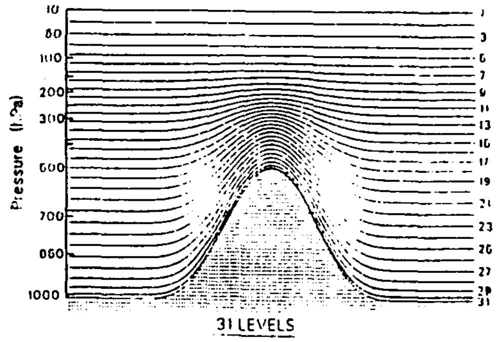


ΔS = 125 km





ΔS = 62 km



SSM/I at ECMWF

THE WETNET PROGRAM

5 years project run by NASA/MSFC

Based on SSM/I data + McIDAS software

Goal: cooperative research
+ EOSDIS preparation

WETNET DATA

SSM/I Brightness temperatures

SSM/I Products

GOES Imagery (Infra-red)

ECMWF receives WetNet data since April 91

Available now: July 87 --> November 87

Total Precipitable Water from SSM/I

Background

$$TPW = \int_{0}^{P_s} g^{-1} q \, dp$$

g: gravity constant

q: water vapour mixing ratio

TPW Units: $kg/m^2 = 0.1\ g/cm^2 = 1.\ mm$

WetNet TPW

Alishouse et al. algorithm (NESDIS)

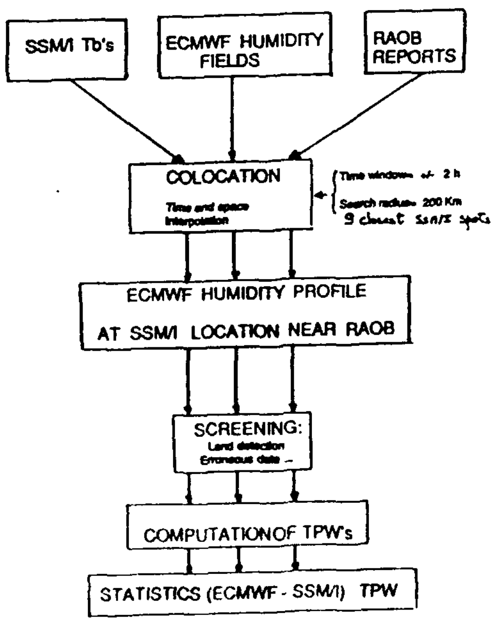
Regression radiosonde TPW vs SSM/I T_b
(for 19 small islands)

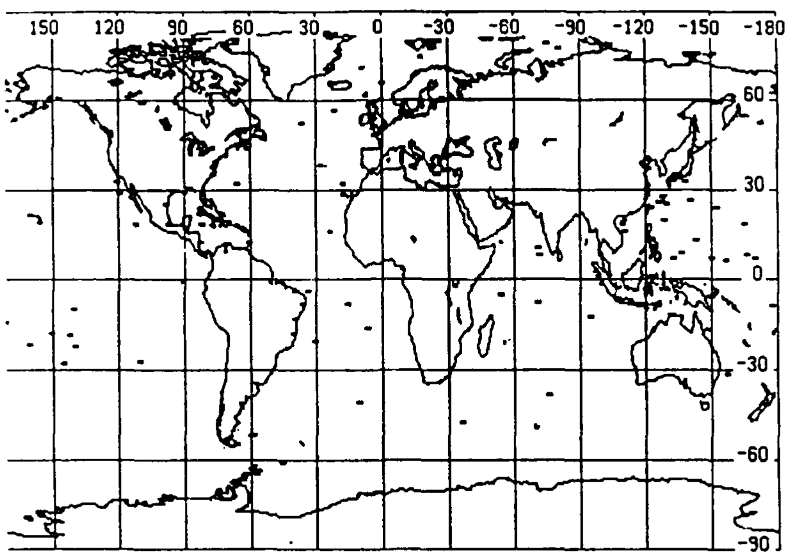
Period July 87 to April 88

Uses 3 channels:

$$TPW = 232. - 0.14\ Tb19v - 1.8\ Tb22v - 0.36\ Tb37v + 0.006\ (Tb22v)^{**}2$$

QUALITY CONTROL OF SSM/I-TPW AT ECMWF





Radiosonde Locations used for SSM/I-TPW Quality Control.

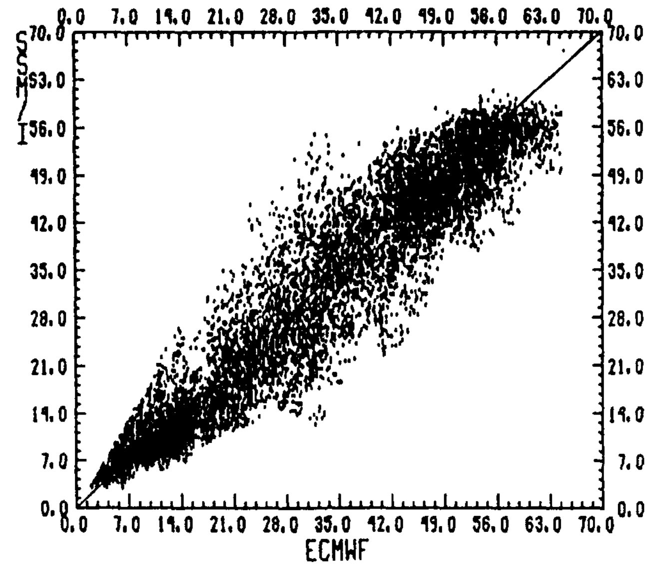
Period: 28 Sept to 25 Oct + 09 Nov to 23 Nov 1987 = 48 days

MODEL - SSM/I at SSM/I location (close to a radiosonde)

Lat		Samp#	Mean Ana	Mean SSM/I	S.D. Ana	S.D. SSM/I	Bias	S.D.
90.	60.	1891	10.3	10.8	4.2	3.8	-0.5	2.4
60.	55.	847	11.0	11.1	4.9	3.8	-0.1	2.3
55.	25.	6226	25.3	25.2	13.0	12.9	0.1	4.9
25.	20.	914	44.8	44.0	9.8	10.1	0.8	4.8
20.	0.	3604	47.8	48.2	8.6	7.5	-0.4	5.8
0.	-20.	353	50.2	48.9	6.4	7.3	1.3	4.5
-20.	-25.	0	0.0	0.0	0.0	0.0	0.0	0.0
-25.	-55.	252	20.9	18.8	7.4	7.8	2.1	4.4
-55.	-60.	0	0.0	0.0	0.0	0.0	0.0	0.0
-60.	-90.	26	6.9	11.2	2.2	3.3	-4.3	1.6
Total 90.	-90.	14113	30.0	30.0	17.2	17.0	0.0	4.8

$\simeq$ 1500 raobs

28/09/87 to 25/10/87
+ 05/11/87 to 23/11/87 | 48 days ± 14000 colocations
± 1500 raobs



COMPARISON BETWEEN ECMWF ANALYSED HUMIDITY AND SSM/I-TPW FIELDS

ANALYSED HUMIDITY FIELDS

Period: July to December 87

T106 Analysis (resolution=125 km)

4 analysed fields per day (00, 06, 12, 18 UTC)

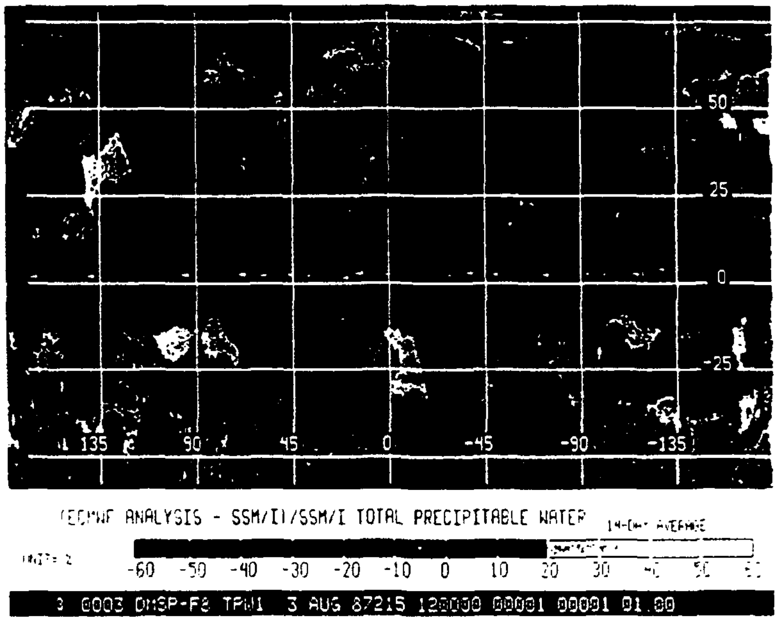
Average over 14 days (56 fields)

SSM/I TPW FIELDS

Available over sea only

65 km resolution

Average over 14 days (ascend. + descend. orbits)



COMPARISON BETWEEN ECMWF HUMIDITY AND SMMR-TPW

Scanning Multichannel Microwave Radiometer

- Aboard Nimbus7 (1978) and Seasat
- Frequencies: 6., 10, 18., 21., 37. GHz (VH)
- Products: as for SSM/I in particular TPW

ECMWF vs. SMMR-TPW

- Study done by Eymard et al. (JAOT, 1989)
- Comparison for 20 days average (Jan.-Feb 79)
- Analysis run for FGGE purposes

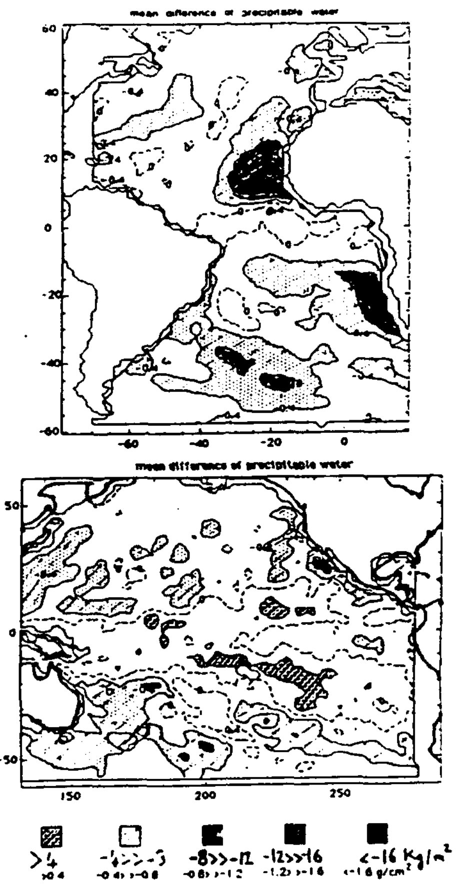


FIG. 9 Mean differences between EC and SMMR precipitable water contents

IMPACT OF CLOUDS ON SSM/I-TPW RETRIEVAL

Sensitivity of TPW to clouds

Cloud described by:
Liquid water density (d in g/m^3)
Base and Top of the cloud (Z_b,Z_t in m)
-> $CLW = d*(Z_t-Z_b)$

Sensitivity:

$$S = \delta TPW/\delta CLW = \sum^{N} (\delta TPW/\delta T_{bi})*(\delta T_{bi}/\delta CLW)$$

$\delta T_{bi}/\delta CLW$ is evaluated with a RT model

Results

S < 0 -> TPW is under-estimated in presence of clouds

ECMWF-SSM/I<0 cannot be explained by clouds (at least not those used in this study)

Stratus clouds do not explained large positive differences

Table 3: Sensitivity of SSM/I total precipitable water
to cloud liquid water

Cloud Layer mBar	Liquid Density g/m³	Mid-Lat Sensit.	Subarctic Sensit.	Tropical Sensit.
950-900	0.1	-6.88	-3.77	-5.07
900-850	0.1	-7.57	-3.75	-5.05
850-800	0.1	-7.77	-3.57	-5.73
700-650	0.1	-8.69	-2.68	-7.25
950-900	1.	-4.43	-	-3.85
900-850	1.	-4.60	-	-3.97
850-800	1.	-4.32	-	-4.10
700-650	1.	-3.06	-	-4.64

The sensitivity is unitless (i.e. $kg.m^{-2}/kg.m^{-2}$)

How to read this table:

for a cloud layer of thickness 950-900 mb, i.e. about 500 m, with a density of .1 g/m³ the cloud liquid content (CLW) is :

CLW= 500 m * 0.1E-3 kg/m³ = 0.05 kg/m²

The error in TPW due to cloud is then for example:

S*CLW=-6.88*0.05=0.344 kg/m²

SUMMARY

Good agreement between SSM/I-TPW and ECMWF analyses near radiosondes.

For some areas, large differences between ECMWF and SSM/I-TPW have been found and they cannot be explained by clouds only. Further investigations are in progress.

It is expected that SSM/I-TPW assimilation experiment will start soon at ECMWF.

METEOROLOGICAL IMPACT OF SURFACE WIND DIRECTIONS MEASURED BY OVER-THE-HORIZON RADAR (OTHR) AND WIND SPEEDS MEASURED BY THE SPACEBORNE SSM/I MICROWAVE RADIOMETER

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T.M. Georges

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325 Broadway
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The lack of adequate observational data has been recognized as a major factor limiting the validity of weather forecasts. Numerical Weather Prediction, NWP, models require the complete specification of initial state variables, yet only a fraction of such data are available at any given time. Remotely sensed measurements offer an effective way to supplement those from the conventional synoptic network. The present tests were conducted to demonstrate the impact on NWP of sea surface wind speeds obtained from the SSM/I spaceborne microwave sensor on DMSP and the sea surface wind directions obtained from Air Force Over the Horizon Radars, OTH-B. Georges et al. (1990) showed that those DoD surveillance OTHRs provide a unique opportunity to obtain meteorological data from distances within 2000 km of the east and west coasts of the United States.

Quantitative surface winds were measured from the west coast OTH-B during one week in May 1991 and from the east coast OTH-B during a week in June 199'. Those data were incorporated into the Goddard Laboratory for Atmospheres NWP model along with wind speeds measured by SSM/I. Results of this analysis will be presented and the impact of the sea surface wind velocity measurements will be discussed.

Georges, T.M., G.D. Thome, 1990: An opportunity for Long-Distance Oceanographic and Meteorological Monitoring Using Over-The-Horizon Defense Radars, Bull. Am. Met. Soc., 71, 1739-1745.

METEOROLOGICAL IMPACT OF SURFACE WIND DIRECTIONS MEASURED BY OVER-THE-HORIZON RADAR (OTHR) AND WIND SPEEDS MEASURED BY THE SPACEBORNE SSM/I MICROWAVE RADIOMETER.

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T.M. GEORGES (2)

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Boulder, CO 80303

NEED FOR REMOTELY SENSED SURFACE WIND DATA

SURFACE WIND VELOCITY MEASUREMENTS ARE REQUIRED TO:

1. DRIVE OCEAN MODELS AND SURFACE WAVE MODELS.

2. CALCULATE SURFACE HEAT, MOISTURE AND MOMENTUM FLUXES

3. CONSTRUCT CLIMATOLOGIES OF SURFACE FIELDS.

4. STUDY A WIDE RANGE OF ATMOSPHERIC AND OCEANIC PHENOMENA -SUCH AS EXPLOSIVE CYCLOGENESIS, FORMATION OF SST ANOMALIES AND OTHER ASPECTS OF AIR-SEA INTERACTION.

5. IMPROVE NUMERICAL WEATHER PREDICTION - BY PROVIDING BOTH INITIAL DATA AND VERIFICATION DATA FOR MODEL PREDICTIONS AND PARAMETERIZATIONS.

CONVENTIONAL DATA OVER THE OCEANS IS NOT ADEQUATE FOR THESE APPLICATIONS -DATA IS USUALLY SPARSE AND NOT OF SUFFICIENT ACCURACY

Table I-1. Conventional Ocean Surface Wind Stress

Type	Time Period	Spatial Coverage	Temporal Sampling	Notes
Ship reports	1850 to present	Global, but sporadic	Highly variable with location and time	Typically of poor accuracy
Ocean Weather Ships	1950 to late 1970's	Fewer than a dozen ships, mid-latitudes	Several times a day at fixed stations	Discontinued
Moored platforms	1960 to present	Predominantly near coasts	Several times a day at fixed stations	
Inferred from surface pressure maps	1960 to present	Extra-tropical	Typically 2-4 per day	Requires assumed model relating pressure to wind
Islands	1950's to present	Generally poor	Several times per day	May be affected by micro-meteorological factors

OTHER POSSIBILITIES FOR SURFACE WINDS

- NEW SCATTEROMETER LAUNCHES

  ERS-1 (1991)

  NSCAT (1996)

  THESE SATELLITES WILL YIELD GREATLY IMPROVED WINDS; MORE ACCURATE AND WITH FEWER AMBIGUITIES.

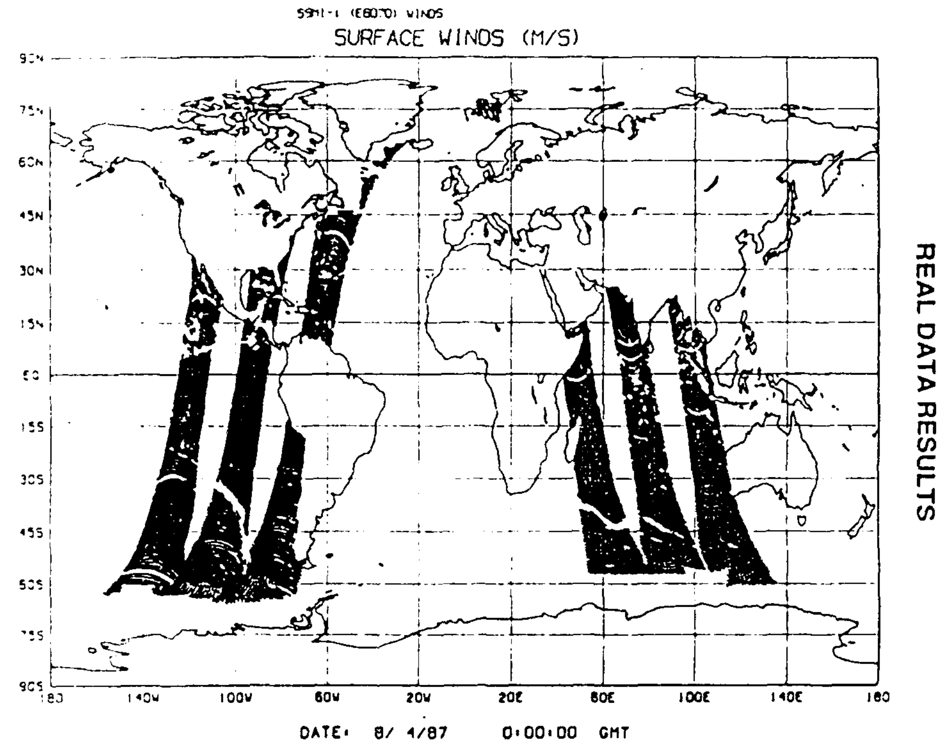
- SEVERAL SOURCES EXIST NOW FOR SURFACE WIND SPEEDS

  GEOSAT (ALTIMETER)

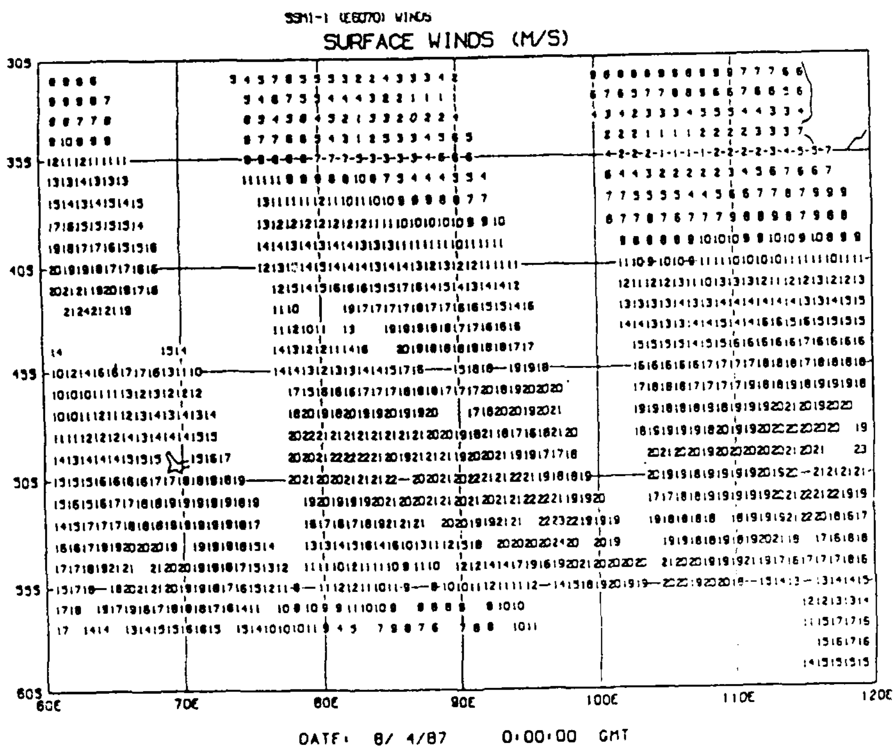
  NIMBUS-7 (SMMR)

  DMSP (SSMI)

- HOWEVER -- DIRECTIONS MUST BE INFERRED FOR THESE WIND SPEED DATA IN ORDER TO USE THEM IN CURRENT ANALYSIS/FORECAST SYSTEMS.



REF 15.00 SSMI WINDS AFTER DIRECTION ASSIGNMENT FOR 0000GMT 4 AUG. 1987 +/- 3 HOURS MAX 40.00



SAMPLE OF SSMI WIND SPEEDS SHOWING INTERNAL CONSISTENCY AND COHERENCY

METHODS TO ASSIGN DIRECTIONS

TO WIND SPEED DATA

1. Use "first guess" wind directions from a GCM
   > Wind component interpolated to obs locations; resulting directions assigned to speed data.
   > Places complete reliance on quality of GCM (6 H) forecast.

2. Use analyzed wind directions (STD ANALYSIS)
   > Analyze all conventional data in a first step; then interpolate analyzed winds to observation locations.

   > Less of a reliance on the quality of the GCM first guess.

   > Similar in nature to the GLA objective dealiasing of SASS winds.

3. Use analyzed surface pressures (EKMAN BALANCE)
   > Very similar to the approach described in Yu (1987).
   > This method involves estimating the surface drag from the wind speeds, first guess pressure gradients, and an assumed balance (Ekman Balance) relation. Wind vectors are then generated from these quantities. There is no input from the model first guess winds.

4. Use analyzed surface pressures and winds (HYBRID)
   > Combines previous two methods; uses model winds everywhere but in those areas (e.g. South Polar regions) where the Ekman Balance assumption yields better results than the model; a result of very sparse conventional data.

5. Use analyzed surface pressures and winds (GEN'L BAL)

> A generalization of the Ekman Balance; more terms from the momentum equation are used to estimate the directions.

> This approach should extend the range of validity (compared to Ekman approach) in relation to the model first guess.

6. Use surface pressures and winds (VARIATIONAL)

> Basically like std analysis method; a high resolution variational analysis combining first guess, conventional data and surface wind speed data is performed. Direction of analyzed surface vector wind assigned to the speed data

> Variational analysis step can contain weights relating quality of the first guess to the other data sources. Explicit dynamical balances, as well as constraints on smoothness can be put into the functional.

GLOBAL DIRECTIONAL ERROR (IN DEGREES) AFTER ANALYSIS OF SIMULATED DATA

METHOD	0-5m/s	5-10 m/s	10-15 m/s	15-20 m/s	ALL SPEEDS
1	41.8	18.8	18.0	24.9	27.2
2	35.0	16.1	17.3	23.1	23.3
3	62.3	30.8	17.4	9.0	40.1
4	35.0	14.9	12.2	6.3	21.8
6	33.8	15.0	14.4	20.4	21.9
number:	532	681	218	15	1446

Method 1: Model first guess
Method 2: Analyzed wind directions
Method 3: Ekman balance
Method 4: Hybrid (combination of methods 2 and 3)
Method 5: General balance
Method 6: Variational analysis

GENERAL BALANCE DIRECTION ASSIGNMENT METHOD

- Basis for method: SPEED EQUATION

$$\frac{\partial S}{\partial t} + \vec{V}\cdot\nabla S + \omega\frac{\partial S}{\partial P} + \frac{1}{\rho}\frac{\vec{V}}{S}\cdot\nabla P + C_D S^2 = 0$$

- If $\vec{V} = S\,COS\gamma\,\vec{i} + S\,SIN\gamma\,\vec{j}$ then the direction equation is:

$$\boxed{\left[S\frac{\partial S}{\partial x} + \frac{1}{\rho}\frac{\partial P}{\partial x}\right]COS\gamma + \left[S\frac{\partial S}{\partial y} + \frac{1}{\rho}\frac{\partial P}{\partial y}\right]SIN\gamma = -\left[\frac{\partial S}{\partial t} + \omega\frac{\partial S}{\partial P} + C_D S^2\right]}$$

- ▹ Bracket terms multiplying the SIN,COS terms are affected by Pressure data and the SSM/I speed data
- ▹ A simple scalar analysis of SSM/I speed performed, then gradients are calculated
- ▹ A diagnostic relation, also using the SSM/I speed data, is used to estimate the friction term $C_D S^2$
- ▹ All other terms are estimated from the GCM first guess

COMPARISON OF METHODS 1 AND 5 USING SIMULATED DATA

NATURE RUN
(PERFECT) SSM/I
SURFACE WINDS

GENERAL BALANCE
SSM/I SURFACE WIND
VECTORS

METHOD 1
SSM/I SURFACE WIND
VECTORS

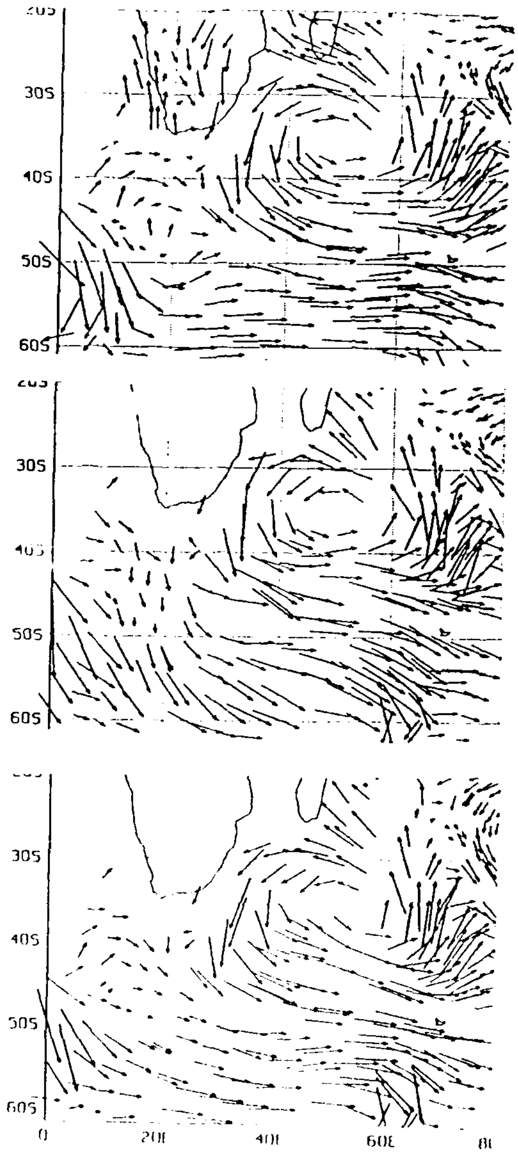


Fig. 13

VARIATIONAL DIRECTION ASSIGNMENT FOR SSM/I WIND SPEEDS

PROBLEM: Want surface vector winds from SSM/I data

GIVEN:

(1) Sparse Conventional data (ships, buoys)
(2) First guess (ECMWF analysis)
(3) SSM/I surface wind speeds
(4) Kinematic, dynamic constraints (smoothness, divergence, vorticity tendency)

METHOD: Obtain analyzed wind V_a by performing a variational analysis using the given information; assign the resulting direction to the SSM/I wind speeds:

> Construct a functional F consisting of terms measuring the departure of a solution (wind vectors) from the above terms.

> Find the solution which <u>minimizes</u> F using a <u>direct minimization</u> algorithm. Follows work at GLA by R. Hoffman on dealiasing SEASAT winds.

> Interpolate the directions of V_a to the SSM/I locations - these are the assigned directions of Method 6

CHECKING: Resulting wind vectors are checked against a set of withheld buoys.

For our analysis, we minimize the following functional F:

$$F = \lambda_1 S_c + \lambda_2 S_f + \lambda_3 S_s + \lambda_4 S_{vel} + \lambda_5 S_{div} + \lambda_6 S_{vor} + \lambda_7 S_{dyn}$$

Here, the λ-weights control the amount of influence each constraint has on the final analysis.

Penalty terms used in the functional measuring departures:

- $S_c = \Sigma (V_c - V_a)^2$ from conventional data
- $S_f = \Sigma (V_f - V_a)^2$ from first guess
- $S_s = \Sigma (|V_{ssmi}| - |V_a|)^2$ from SSM/I wind speeds

Three smoothness constraints (vs the first guess)

- $S_{vel} = \Sigma (\nabla^2(u_f - u_a))^2 + \Sigma (\nabla^2(v_f - v_a))^2$
- $S_{div} = \Sigma (\nabla^2(\chi_f - \chi_a))^2$
- $S_{vor} = \Sigma (\nabla^2(\psi_f - \psi_a))^2$

Finally, a dynamical constraint on the <u>analyzed vorticity tendency:</u>

- $S_{dyn} = \Sigma (\partial\zeta_a/\partial t)^2$

QUALITY CONTROL USED IN VARIATIONAL ANALYSIS

Three checks are made to check a wind observation $V_{OBS} = (u_{OBS}, v_{OBS})$ against a reference wind $V_{REF} = (u_{REF}, v_{REF})$, which in this case is taken from the output of the first minimization.

1. <u>Vector velocity differences</u>

$$((u_{OBS} - u_{REF})^2 + (v_{OBS} - v_{REF})^2)^{1/2} \quad > \quad \gamma_1 \; |V_{AV}|$$

where

$$V_{AV} = (V_{OBS} + V_{REF})/2$$

2. Speed differences

$$|\,(|V_{OBS}| - |V_{REF}|)\,| \quad > \quad \gamma_2 \; |V_{AV}|$$

3. Direction differences

$$\cos(\,\theta_{OBS} - \theta_{REF}\,) \quad > \quad \gamma_3 \; \cos(\,\theta_{CUT}\,)$$

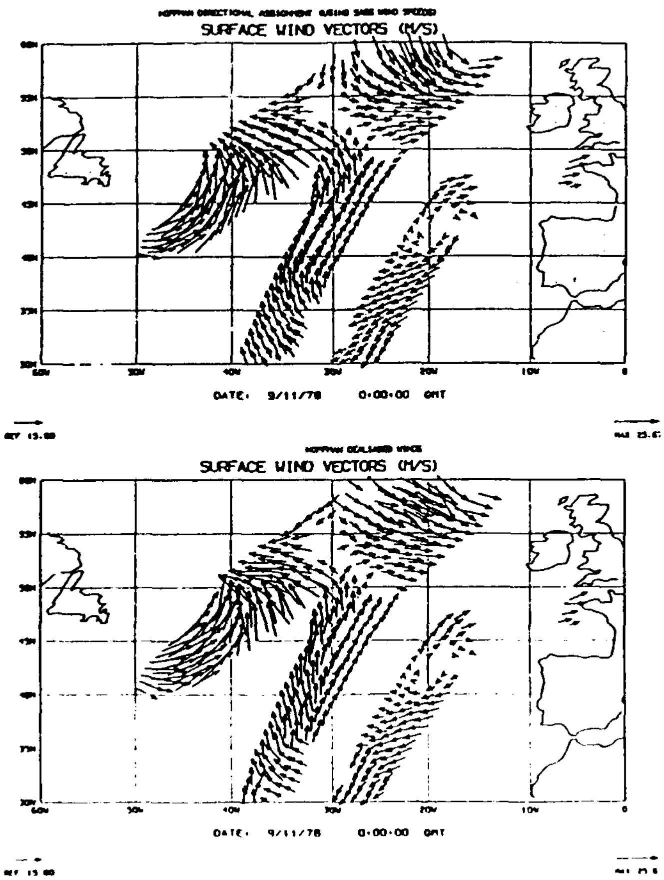
here we use θ_{CUT} = 60 degrees.

F is minimized by means of two direct minimization steps:

1. First step uses all conventional data, using a loose convergence criterion. (The conventional data were subject to a mild quality control in a pre-processing step)
2. Repeat the minimization process, but now perform gross checks on the conventional data (vs the first minimization field). Use a tighter convergence criterion, since the first step should get a solution near the global minimum of F.

The current version of the variational analysis uses the same λ's for both steps; the greatest weights are given to the conventional data and the SSM/I speeds, the least weights are given to the smoothness constraints and the first guess.

COMPARISON OF DIRECTIONAL ASSIGNMENT VS. DEALIASING OF REAL SEASAT SCATTEROMETER DATA USING METHOD 6



JULY-OCTOBER COLLOCATION STATISTICS USING INDEPENDENT DATA

SSM/I (METHOD 6) VS WITHELD BUOYS

	MEAN ABSOLUTE ERROR	BIAS
WIND SPEED:	1.7 m/s	0.24 m/s
DIRECTION:	21.7 deg	0.10 deg

NUMBER OF COLLOCATIONS: 3870

SSM/I (METHOD 6) VS PMEL BUOYS

	MEAN ABSOLUTE ERROR	BIAS
WIND SPEED:	1.7 m/s	-1.6 m/s
DIRECTION:	27.5 deg	-6.1 deg

NUMBER OF COLLOCATIONS: 124

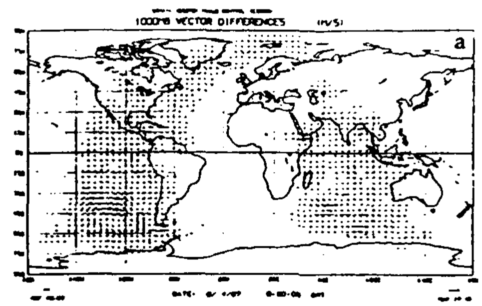


Figure 1a. Vector difference of 1000 mb analyzed winds. SSM/I minus Control. Satellite swath is evident in the difference field.

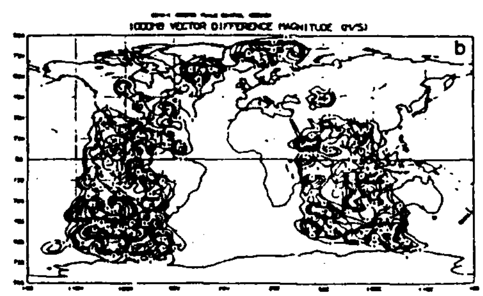


Figure 1b. Magnitudes of vectors in Fig 1a, maximum value is 17.4 m/sec. Largest impact of SSM/I on the analysis occurs in the Southern Hemisphere.

IMPACT OF SSMI DATA ON GLA ANALYSIS FOR 4 AUG. 1987

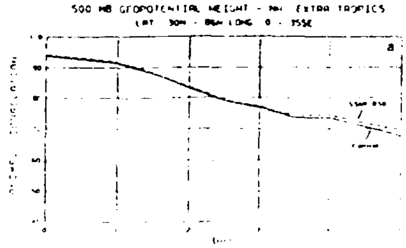


Figure 2a. Northern Hemisphere 500 mb height anomaly correlations for two cases Control and Control + SSM/I (up to 850 mb)

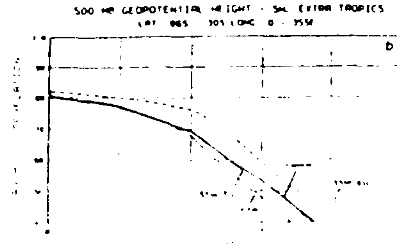
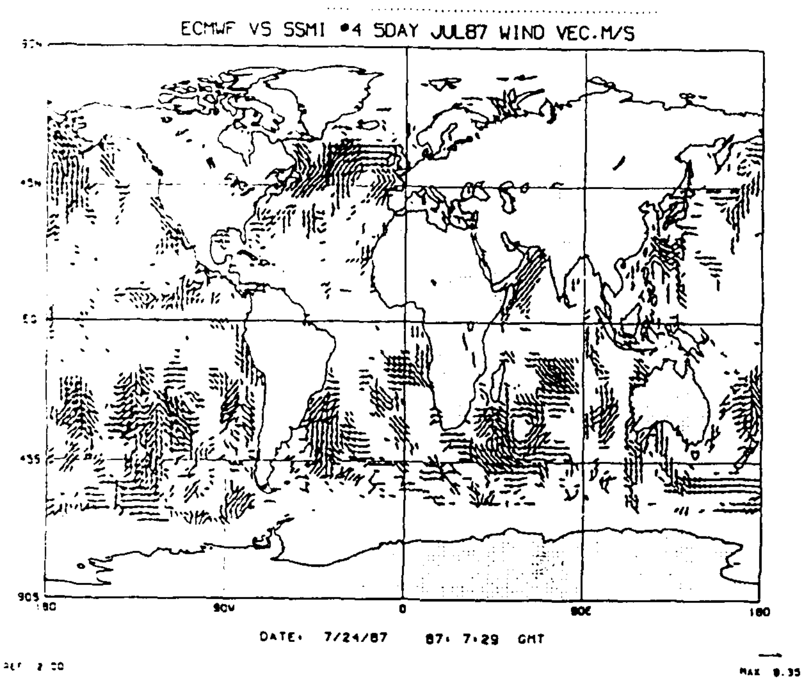


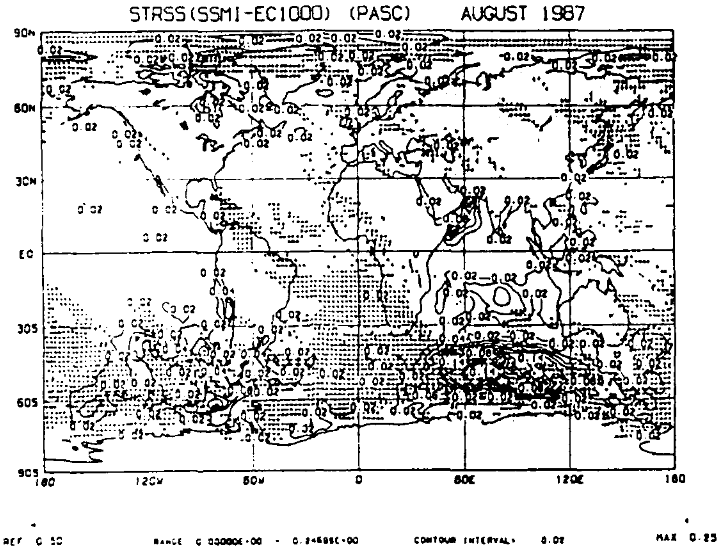
Figure 2b. Southern Hemisphere 500 mb height anomaly correlations for four cases Control (C), C + SSM/I (surface only), C + SSM/I (up to 850 mb) and C + cloud tracked winds



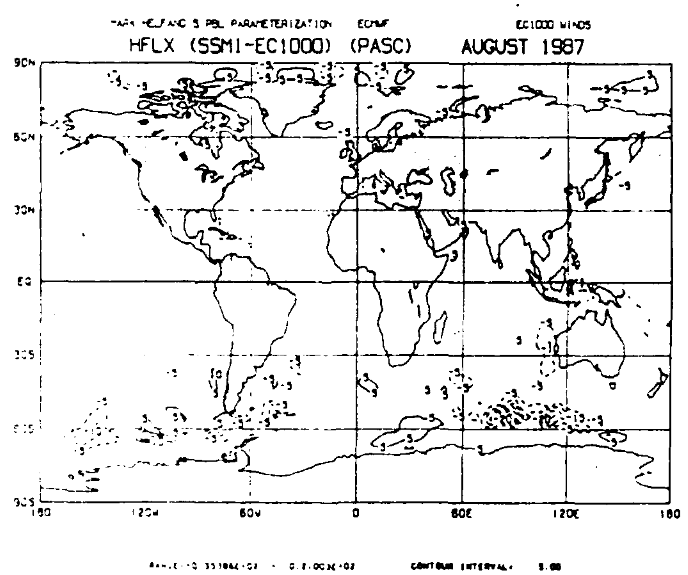
COMPONENTS OF THE GLA GCM PBL SCHEME
(Helfand and Labraga)

- A level 2.5, second-order turbulence closure model (Mellor and Yamada, 1974; Yamada, 1977; Helfand and Labraga, 1988)
- A Monin-Obukhov similarity scheme for the "Extended Surface Layer"
- A parameterization for the viscous sublayer
- Parameterizations to predict the surface roughness parameter z_0 over land and sea

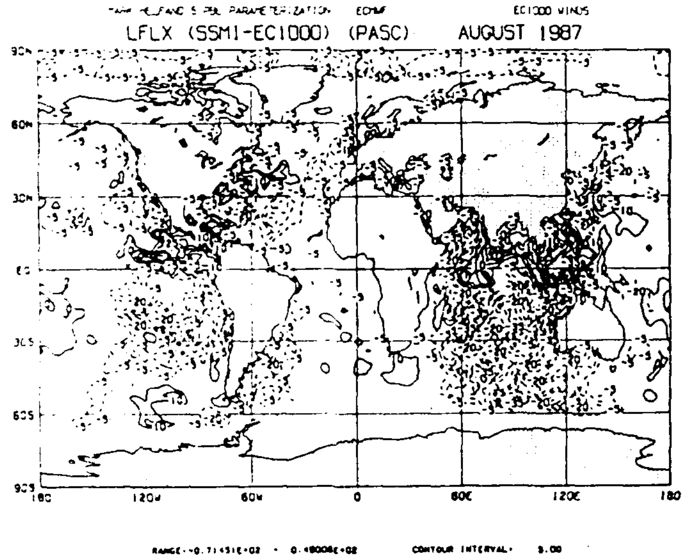
Impact of SSMI WINDS on Surface Wind STRESS
(relative to ECMWF WINDS)



Impact of SSMI WINS on Sensible Air-Sea heat flux

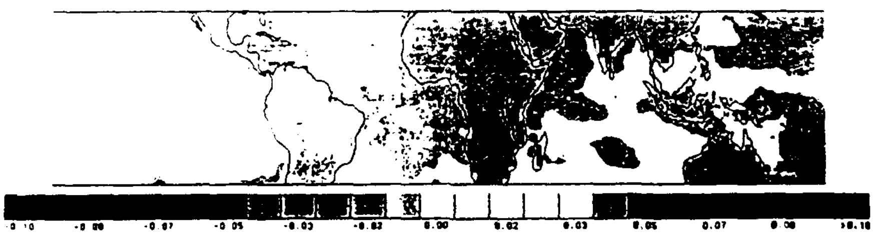


Impact of SSMI Winds on Latent Heat Flux



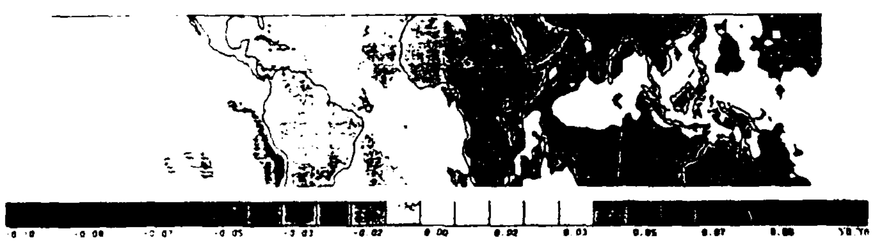
Impact of SSMI Surface Winds on Air-Sea U-Wind Stress (N/m^2)

August 1987



Impact of SSMI Surface Winds on Air-Sea V-Wind Stress (N/m^2)

August 1987

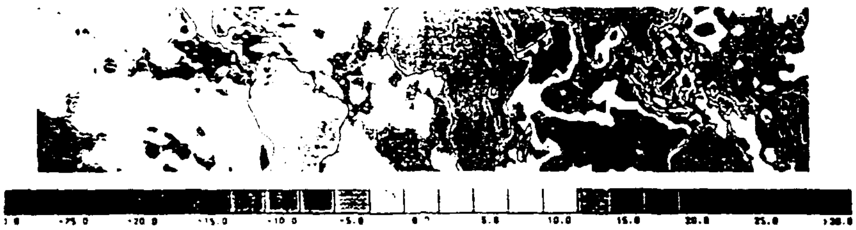


pact of SSMI Surface Winds on Air-Sea Sensible Heat Flux (W/m^2)

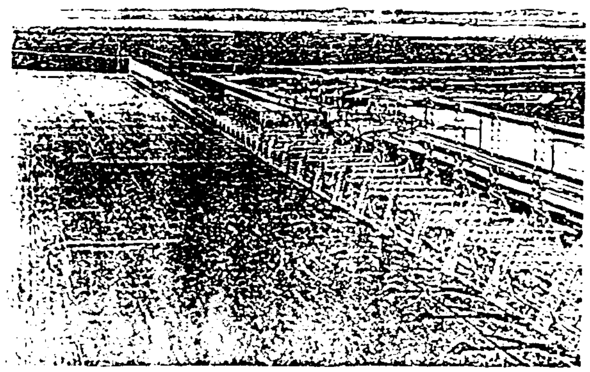
August 1987

mpact of SSMI Surface Winds on Air-Sea Latent Heat Flux (W/m^2)

August 1987

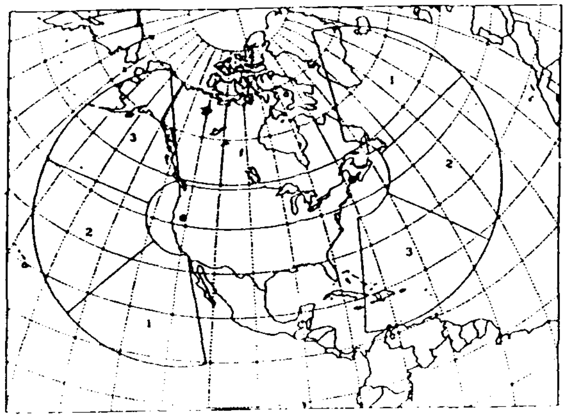


<u>What does an OTH radar look like</u> ?



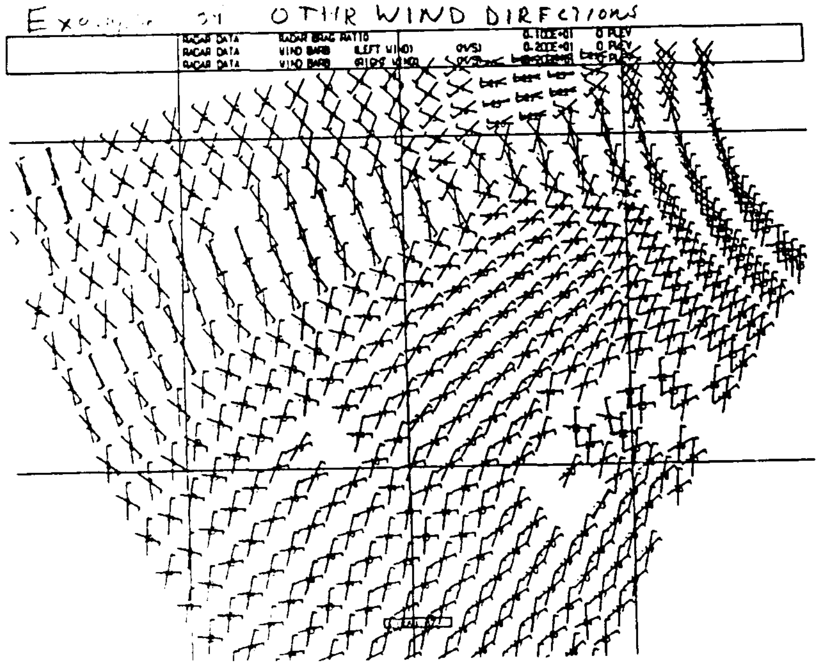
[illegible]

How far can OTH radars see?

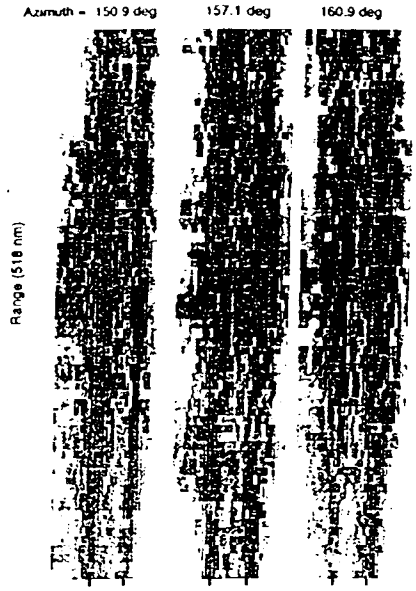


These two OTH-B air-defense radars operated by the U. S. Air Force on the U. S. east and west coasts cover about 20-million square kilometers each. For one ionospheric bounce, their nominal maximum range is 2000 nmi (3704 km)

Example 31 OTHR WIND DIRECTIONS

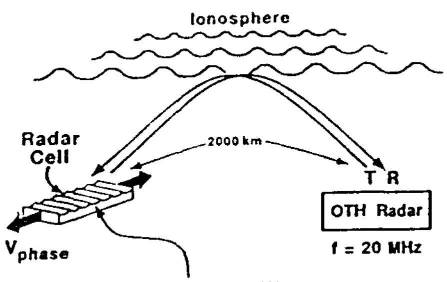


How does the ionosphere distort the spectrum of the sea echo?



This range-Doppler plot shows how the Bragg lines of the sea echo are shifted and spread in frequency by reflection from an irregular ionosphere. Tick marks at the bottom indicate the theoretical Doppler shifts of the sea echo Bragg lines, and the Doppler-shift scale goes from +1.25 Hz to -1.25 Hz. *The relative strengths of the advancing and receding Bragg lines in the three beams reveal the circulation in hurricane Claudette*

How does OTH Radar detect sea-surface conditions?



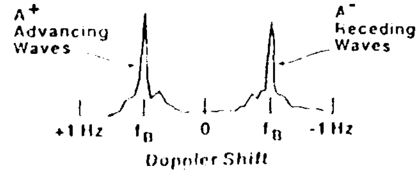
Bragg-Resonant Ocean Waves:

$$\lambda_{ocean} = \frac{1}{2}\lambda_{radar} = 7.5 \text{ m}$$

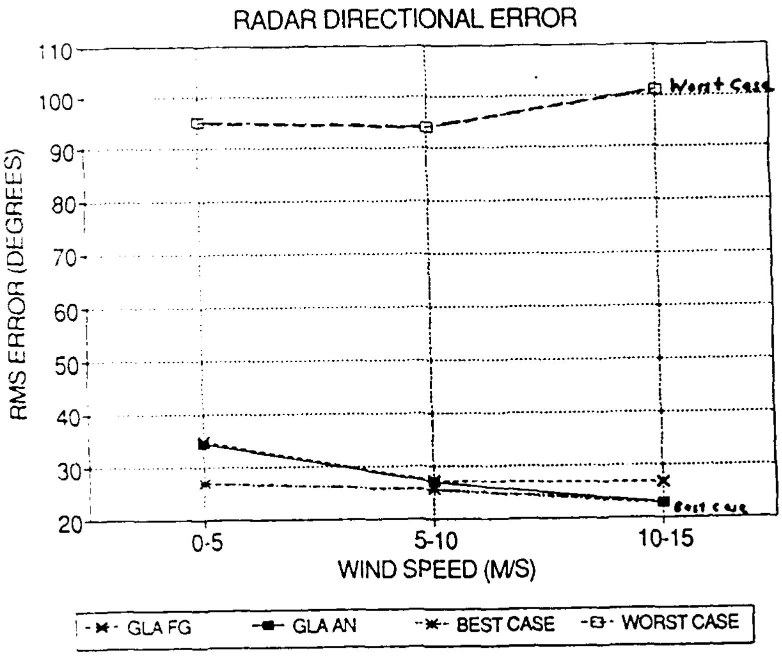
$$V_{phase} = \sqrt{\frac{g\lambda_{ocean}}{2\pi}} = 3.4 \text{ m/s}$$

$$\text{Doppler Shift } f_B = \pm 0.1\sqrt{f_{MHz}} = \pm 0.45 \text{ Hz}$$

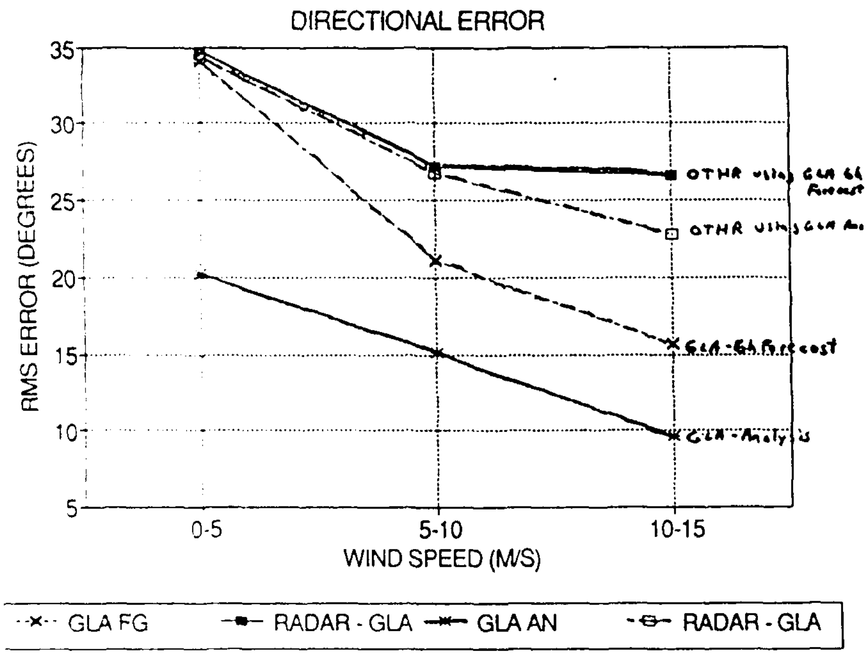
Sea-Echo Spectrum:



The spectrum of "surface clutter" from moving ocean waves, normally discarded in defense applications, contains information about ocean surface conditions



RADAR DIRECTIONAL ERROR
RMS ERROR (DEGREES)
110
100
90
80
70
60
50
40
30
20
0-5
5-10
10-15
WIND SPEED (M/S)
Worst Case
Best Case
GLA FG
GLA AN
BEST CASE
WORST CASE



DIRECTIONAL ERROR
RMS ERROR (DEGREES)
35
30
25
20
15
10
5
0-5
5-10
10-15
WIND SPEED (M/S)
GLA-Analysis
GLA FG
RADAR - GLA
GLA AN
RADAR - GLA

Worst Case Dealiasing

Period: May 13 - May 18 1991

Summary:

Colocations vs GLA First Guess
OTH Dealiased by choosing alias that is farthest away from colocated conventional report
Quality Control performed using NMC Analysis

Radar (R) and First Guess (F) Directional Error Statistics Binned by Wind Speed

SPEED (M/S)	RMS ERROR	MEAN ERROR	ABSOLUTE ERROR	COUNT
0 --> 5	R 85.29 F 34.[illegible]	R -7.59 F [illegible]	R 82.16 F 27.19	R 35.00 F 35.00
5 --> 10	R 94.01 F 21.[illegible]	R 1.[illegible] [illegible]	R [illegible] F 16.85	R 88.00 F 88.00
10 --> 15	R 101.29 F 15.68	R -5.0[illegible] F [illegible]	R [illegible] F 12.55	R 42.00 F 42.[illegible]
15 --> 20	R 0.00 F 0.00	R 0.00 F 0.00	R 0.00 F 0.00	R 0.00 F 0.00
>= 20	R 0.00 F 0.00	R 0.00 F 0.00	R 0.00 F 0.00	R 0.00 F 0.00
TOTALS	R 96.18 F 23.38	R -2.21 F -0.63	R 84.22 F 17.95	R 165.00 F 165.00

Radar (R) and First Guess (F) [illegible]ectional Error Statistics Binned by Brag Ratio

BRAG RATIO	RMS ERROR	MEAN ERROR	ABSOLUTE ERROR	COUNT
0 --> 5	R 150.61 F 35.41	R -17.75 F 3.99	R 148.71 F 26.73	R 26.00 F 26.00
5 --> 10	R 133.00 F 19.32	R -49.99 F 0.25	R 129.13 F 17.03	R 23.00 F 23.00
10 --> 15	R 91.80 F 24.02	R 20.14 F 1.09	R 86.98 F 18.84	R 38.00 F 38.00
15 --> 20	R 54.53 F 18.55	R -8.50 F -3.12	R 51.23 F 14.77	R 66.00 F 66.00
>= 20	R 33.35 F 19.12	R 17.56 F -4.01	R 31.21 F 15.35	R 12.00 F 12.00
TOTALS	R 96.18 F 23.38	R -2.21 F -0.63	R 84.22 F 17.95	R 165.00 F 165.00

Radar Counts for Brag Ratio vs Directional Error Bins

	DIRECTIONAL ERROR					
BRAG RATIO	0 --> 20	20 --> 40	40 --> 60	60 --> 80	>= 80	TOTALS
0 --> 5	0	0	0	0	26	26
5 --> 10	0	0	0	3	20	23
10 --> 15	0	1	7	9	21	38
15 --> 20	1	21	26	11	7	66
>= 20	2	9	1	0	0	12
TOTALS	3	31	34	23	74	165

Radar Counts for Speed vs Directional Error Bins

	DIRECTIONAL ERROR					
SPEED (M/S)	0 --> 20	20 --> 40	40 --> 60	60 --> 80	>= 80	TOTALS
0 --> 5	1	7	7	6	14	35
5 --> 10	2	21	16	12	37	88
10 --> 15	0	3	11	5	23	42
15 --> 20	0	0	0	0	0	0
>= 20	0	0	0	0	0	0
TOTALS	3	31	34	23	74	165

Average Radar Theta for Brag Ratio vs Wind Speed Bins
() denotes number of reports used in average

	SPEED (M/S)					
BRAG RATIO	0 --> 5	5 --> 10	10 --> 15	15 --> 20	>= 20	TOTALS
0 --> 5	62.96 (7)	69.88 (12)	102.06 (7)	0.00 (0)	0.00 (0)	76.68 (26)
5 --> 10	42.88 (5)	87.54 (12)	80.27 (6)	0.00 (0)	0.00 (0)	75.93 (23)
10 --> 15	93.55 (7)	85.91 (22)	68.60 (9)	0.00 (0)	0.00 (0)	83.22 (38)
15 --> 20	76.52 (11)	93.06 (35)	79.71 (20)	0.00 (0)	0.00 (0)	86.25 (66)
>= 20	103.01 (5)	103.23 (7)	0.00 (0)	0.00 (0)	0.00 (0)	103.14 (12)
TOTALS	76.19 (35)	88.17 (88)	81.13 (42)	0.00 (0)	0.00 (0)	83.84 (165)

Best case dealiasing

Period: May 13 - May 18 1991

Summary:

Colocations vs GLA First Guess
OTH Dealiased by choosing closest alias to colocated conventional report
Quality Control performed using NMC Analysis

Radar (R) and First Guess (F) Directional Error Statistics Binned by Wind Speed

SPEED (M/S)	RMS ERROR	MEAN ERROR	ABSOLUTE ERROR	COUNT
0 --> 5	R 27.01 F 34.13	R 4.07 F 3.58	R 20.91 F 27.19	R 35.00 F 35.00
5 --> 10	R 25.52 F 21.09	R 1.63 F -2.39	R 20.25 F 16.85	R 88.00 F 88.00
10 --> 15	R 22.82 F 15.68	R -5.61 F -0.43	R 18.71 F 12.55	R 42.00 F 42.00
15 --> 20	R 0.00 F 0.00	R 0.[illegible] F 0.00	R 0.00 F 0.00	R 0.00 F 0.00
>= 20	R 0.00 F 0.00	R 0.00 F 0.00	R 0.00 F 0.00	R 0.00 F 0.00
TOTALS	R 25.19 F 23.38	R 0.30 F -0.63	R 20.00 F 17.95	R 165.00 F 165.00

Radar (R) and First Guess (F) Directional Error Statistics Binned by Brag Ratio

BRAG RATIO	RMS ERROR	MEAN ERROR	ABSOLUTE ERROR	COUNT
0 --> 5	R 34.02 F 35.41	R -1.21 F 3.99	R 28.68 F 26.73	R 26.00 F 26.00
5 --> 10	R 31.42 F 19.32	R -3.55 F 0.25	R 25.31 F 17.03	R 23.00 F 23.00
10 --> 15	R 27.47 F 24.02	R -2.44 F 1.09	R 23.76 F 18.84	R 38.00 F 38.00
15 --> 20	R 17.27 F 18.55	R 2.20 F -3.12	R 14.00 F 14.77	R 66.00 F 66.00
>= 20	R 15.02 F 19.12	R 9.22 F -4.01	R 12.05 F 15.35	R 12.00 F 12.00
TOTALS	R 25.19 F 23.38	R 0.30 F -0.63	R 20.00 F 17.95	R 165.00 F 165.00

Radar Counts for Brag Ratio vs Directional Error Bins

	DIRECTIONAL ERROR					
BRAG RATIO	0 --> 20	20 --> 40	40 --> 60	60 --> 80	>= 80	TOTALS
0 --> 5	13	3	9	1	0	26
5 --> 10	11	7	3	2	0	23
10 --> 15	17	16	5	0	0	38
15 --> 20	48	16	2	0	0	66
>= 20	11	1	0	0	0	12
TOTALS	100	43	19	3	[illegible]	165

Radar Counts for Speed vs Directional Error Bins

	DIRECTIONAL ERROR					
SPEED (M/S)	0 --> 20	20 --> 40	40 --> 60	60 --> 80	>= 80	TOTALS
0 --> 5	20	8	6	1	0	35
5 --> 10	54	23	9	2	0	88
10 --> 15	26	12	4	0	0	42
15 --> 20	0	0	0	0	0	0
>= 20	0	0	0	0	0	0
TOTALS	100	43	19	3	0	165

Average Radar Theta for Brag Ratio vs Wind Speed Bins
() denotes number of reports used in average

	SPEED (M/S)					
BRAG RATIO	0 --> 5	5 --> 10	10 --> 15	15 --> 20	>= 20	TOTALS
0 --> 5	62.96 (7)	69.88 (12)	102.06 (7)	0.00 (0)	0.00 (0)	76.68 (26)
5 --> 10	42.88 (5)	87.54 (12)	80.27 (6)	0.00 (0)	0.00 (0)	75.93 (23)
10 --> 15	93.55 (7)	85.91 (22)	68.60 (9)	0.00 (0)	0.00 (0)	83.22 (38)
15 --> 20	76.52 (11)	93.06 (35)	79.71 (20)	0.00 (0)	0.00 (0)	86.25 (66)
>= 20	103.01 (5)	103.23 (7)	0.00 (0)	0.00 (0)	0.00 (0)	103.14 (12)
TOTALS	76.19 (35)	88.17 (88)	81.13 (42)	0.00 (0)	0.00 (0)	83.84 (165)

Dealiasing Using GLA 6h Forecast

Period: May 13 - May 14 1991

Summary:

Colocations vs GLA First Guess
OTH Dealiased using GLA First Guess
Quality Control performed using NMC Analysis

Radar (R) and First Guess (F) Directional Error Statistics Binned by Wind Speed

SPEED (M/S)	RMS ERROR	MEAN ERROR	ABSOLUTE ERROR	COUNT
0 --> 5	R 34.15 F 34.11	R 11.84 F 3.58	R 25.50 F 27.19	R 35.00 F 35.00
5 --> 10	R 27.15 F 21.09	R 0.38 F -2.39	R 21.73 F 16.85	R 88.00 F 88.00
10 --> 15	R 26.60 F 15.68	R -3.42 F -0.43	R 20.20 F 12.55	R 42.00 F 42.00
15 --> 20	R 0.00 F 0.00	R 0.00 F 0.00	R 0.00 F 0.00	R 0.00 F 0.00
>= 20	R 0.00 F 0.00	R 0.00 F 0.00	R 0.00 F 0.00	R 0.00 F 0.00
TOTALS	R 20.81 F 23.30	R 1.44 F -0.63	R 22.16 F 17.95	R 165.00 F 165.00

Radar (R) and First Guess (F) Directional Error Statistics Binned by Brag Ratio

BRAG RATIO	RMS ERROR	MEAN ERROR	ABSOLUTE ERROR	COUNT
0 --> 5	R 41.23 F 35.41	R 9.87 F 3.99	R 32.45 F 26.73	R 26.00 F 26.00
5 --> 10	R 35.04 F 19.32	R -3.90 F 0.25	R 27.49 F 17.03	R 23.00 F 23.00
10 --> 15	R 30.39 F 24.02	R 4.66 F 1.09	R 25.42 F 18.84	R 38.00 F 38.00
15 --> 20	R 20.02 F 18.55	R -1.86 F -3.12	R 16.09 F 14.77	R 66.00 F 66.00
>= 20	R 15.67 F 19.12	R 6.72 F -4.01	R 12.71 F 15.35	R 12.00 F 12.00
TOTALS	R 20.81 F 23.30	R 1.44 F -0.63	R 22.16 F 17.95	R 165.00 F 165.00

Radar Counts for Brag Ratio vs Directional Error Bins

	DIRECTIONAL ERROR					
BRAG RATIO	0 --> 20	20 --> 40	40 --> 60	60 --> 80	>= 80	TOTALS
0 --> 5	13	3	7	1	2	26
5 --> 10	11	7	1	4	0	23
10 --> 15	17	13	7	1	0	38
15 --> 20	44	19	3	0	0	66
>= 20	11	1	0	0	0	12
TOTALS	96	43	18	6	2	165

Radar Counts for Speed vs Directional Error Bins

	DIRECTIONAL ERROR					
SPEED (M/S)	0 --> 20	20 --> 40	40 --> 60	60 --> 80	>= 80	TOTALS
0 --> 5	19	8	4	3	1	35
5 --> 10	52	22	11	3	0	88
10 --> 15	25	13	3	0	1	42
15 --> 20	0	0	0	0	0	0
>= 20	0	0	0	0	0	0
TOTALS	96	43	18	6	2	165

Average Radar Theta for Brag Ratio vs Wind Speed Bins
() denotes number of reports used in average

	SPEED (M/S)					
BRAG RATIO	0 --> 5	5 --> 10	10 --> 15	15 --> 20	>= 20	TOTALS
0 --> 5	62.96 (7)	69.88 (12)	102.06 (7)	0.00 (0)	0.00 (0)	76.68 (26)
5 --> 10	42.88 (5)	87.54 (12)	80.27 (6)	0.00 (0)	0.00 (0)	75.93 (23)
10 --> 15	93.55 (7)	85.91 (22)	68.60 (9)	0.00 (0)	0.00 (0)	83.22 (38)
15 --> 20	76.52 (11)	93.06 (35)	79.71 (20)	0.00 (0)	0.00 (0)	86.25 (66)
>= 20	103.01 (5)	103.23 (7)	0.00 (0)	0.00 (0)	0.00 (0)	103.14 (12)
TOTALS	76.19 (35)	88.17 (88)	81.13 (42)	0.00 (0)	0.00 (0)	83.84 (165)

Dealiasing Using GLA Analysis

Period: May 13 - May 18 1991

Summary:

Colocations vs GLA Analysis
OTH Dealiased using GLA Analysis
Quality Control performed using NMC Analysis

Radar (R) and First Guess (F) Directional Error Statistics Binned by Wind Speed

SPEED (M/S)	RMS ERROR	MEAN ERROR	ABSOLUTE ERROR	COUNT
0 --> 5	R 34.40 F 20.21	R 11.67 F 2.10	R 25.33 F 15.70	R 35.00 F 35.00
5 --> 10	R 26.82 F 15.09	R -1.87 F -0.75	R 21.00 F 11.57	R 88.00 F 88.00
10 --> 15	R 22.82 F 9.64	R -5.61 F 0.14	R 18.71 F 7.54	R 42.00 F 42.00
15 --> 20	R 0.00 F 0.00	R 0.00 F 0.00	R 0.00 F 0.00	R 0.00 F 0.00
>= 20	R 0.00 F 0.00	R 0.00 F 0.00	R 0.00 F 0.00	R 0.00 F 0.00
TOTALS	R 27.70 F 15.22	R 0.05 F 0.08	R 21.34 F 11.42	R 165.00 F 165.00

Radar (R) and First Guess (F) Directional Error Statistics Binned by Brag Ratio

BRAG RATIO	RMS ERROR	MEAN ERROR	ABSOLUTE ERROR	COUNT
0 --> 5	R 37.87 F 23.45	R 4.33 F 3.95	R 30.60 F 18.08	R 26.00 F 26.00
5 --> 10	R 37.37 F 15.78	R -8.85 F -0.46	R 28.97 F 13.01	R 23.00 F 23.00
10 --> 15	R 29.20 F 13.14	R 2.51 F 0.15	R 24.63 F 9.35	R 38.00 F 38.00
15 --> 20	R 17.66 F 11.47	R -1.53 F -0.94	R 14.33 F 9.27	R 66.00 F 66.00
>= 20	R 18.70 F 15.72	R 6.72 F -1.73	R 14.71 F 12.34	R 12.00 F 12.00
TOTALS	R 27.70 F 15.22	R 0.05 F 0.08	R 21.34 F 11.42	R 165.00 F 165.00

Radar Counts for Brag Ratio vs Directional Error Bins

	DIRECTIONAL ERROR					
BRAG RATIO	0 --> 20	20 --> 40	40 --> 60	60 --> 80	>= 80	TOTALS
0 --> 5	13	3	8	1	1	26
5 --> 10	11	6	1	5	0	23
10 --> 15	17	14	7	0	0	38
15 --> 20	47	17	2	0	0	66
>= 20	10	2	0	0	0	12
TOTALS	98	42	18	6	1	165

Radar Counts for Speed vs Directional Error Bins

	DIRECTIONAL ERROR					
SPEED (M/S)	0 --> 20	20 --> 40	40 --> 60	60 --> 80	>= 80	TOTALS
0 --> 5	18	10	3	3	1	35
5 --> 10	54	20	11	3	0	88
10 --> 15	26	12	4	0	0	42
15 --> 20	0	0	0	0	0	0
>= 20	0	0	0	0	0	0
TOTALS	98	42	18	6	1	165

Average Radar Theta for Brag Ratio vs Wind Speed Bins
() denotes number of reports used in average

	SPEED (M/S)					
BRAG RATIO	0 --> 5	5 --> 10	10 --> 15	15 --> 20	>= 20	TOTALS
0 --> 5	62.96 (7)	69.88 (12)	102.06 (7)	0.00 (0)	0.00 (0)	76.68 (26)
5 --> 10	42.88 (5)	87.54 (12)	80.27 (6)	0.00 (0)	0.00 (0)	75.93 (23)
10 --> 15	93.55 (7)	85.91 (22)	68.60 (9)	0.00 (0)	0.00 (0)	83.22 (38)
15 --> 20	76.52 (11)	93.06 (35)	79.71 (20)	0.00 (0)	0.00 (0)	86.25 (66)
>= 20	103.01 (5)	103.23 (7)	0.00 (0)	0.00 (0)	0.00 (0)	103.14 (12)
TOTALS	76.19 (35)	88.17 (88)	81.13 (42)	0.00 (0)	0.00 (0)	83.84 (165)

CONCLUSIONS

1. SSM/I WIND SPEEDS CAN BE EFFECTIVELY ASSIMILATED USING DIRECTIONAL ASSIGNMENT METHODS.

- PRELIMINARY RESULTS SHOW A GENERALLY POSITIVE IMPACT OF SSM/I WINDS IN DATA ASSIMILATION, BUT POTENTIAL FOR NEGATIVE IMPACTS EXISTS, PARTICULARLY WITH SIMPLE DIRECTION ASSIGNMENT METHODS WHERE THE FG DIRECTIONS HAVE LARGE ERRORS.

- CAUTION MUST BE USED IN VERTICALLY EXTENDING THE INFLUENCE OF SURFACE WINDS ABOVE THE PBL. THIS EXTENSION SHOULD DEPEND UPON THE SYNOPTIC SITUATION.

- LARGE POTENTIAL EXISTS FOR SSM/I TO IMPROVE AIR-SEA FLUXES AS PART OF A DATA ASSIMILATION CYCLE; THIS MAY HOLD THE GREATEST POTENTIAL FOR IMPROVING NWP AS WELL.

2. OTHR OBSERVATIONS CONTAIN USEFUL INFORMATION FOR A VARIETY OF METEOROLOGICAL AND OCEANOGRAPHIC APPLICATIONS, BUT THE UTILITY OF THESE DATA ARE LIMITED BY THE DIRECTIONAL AMBIGUITY AND THE OVERLY SIMPLISTIC METHODOLOGY BY WHICH SURFACE WINDS ARE INFERRED.

- THE UTILITY OF OTHR WINDS COULD BE SUBSTANTIALLY ENHANCED BY AN IMPROVED ALGORITHM FOR SURFACE WIND DETERMINATION AND BY THE APPLICATION OF OBJECTIVE AMBIGUITY REMOVAL METHODS, NOT REQUIRING A MODEL FG (eg. AI/PATTERN RECOGNITION/NEURAL NET TECHNIQUES).

OBSERVATIONS OF FLOODED ICE IN ARCTIC REGIONS

Andreas K. Goroch and Robert W. Fett

Naval Oceanographic and Atmospheric Research Laboratory
Atmospheric Directorate
Monterey, CA 93943-5001

The remote detection of flooding of the Arctic ice pack has been difficult to accomplish using conventional methodologies. We have examined a case of flooded Arctic ice with NOAA and DMSP visible and infrared measurements, supplemented by DMSP microwave imager (SSM/I) data. Analysis of visible and infrared data for a sunglint region was used to show the distribution of flooding at 27 N, 135 W on 8 June, 1989.

A simple model is described for the radiative transfer at microwave wavelengths through a brine layer over ice. The predictions of the model were found to be consistent with the spatial behavior of the SSM/I measurements. This case study demonstrated the utility of using combined visible, infrared, and microwave measurements to differentiate among flooded ice, broken ice, and open water regions, even in the presence of cloud cover and surface fog.

Observations of Flooded Ice in Arctic Regions

Andreas K. Goroch and Robert W. Fett

Flooded Ice in Arctic Regions

Purpose

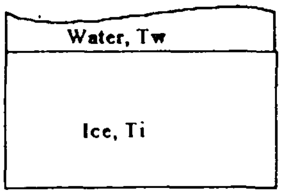
- Identify flooded regions over ice using microwave imagery

Approach

- Develop physical model
- Identify flooded regions with optical imagery (Vis, NIR,MIR,Thermal)
- Identify microwave characteristics

Flooded Ice in Arctic Regions

Physical model



Radiative Transfer Equation

$$\frac{\delta I}{\delta z} = -kI + kS$$

Solution in zenith direction

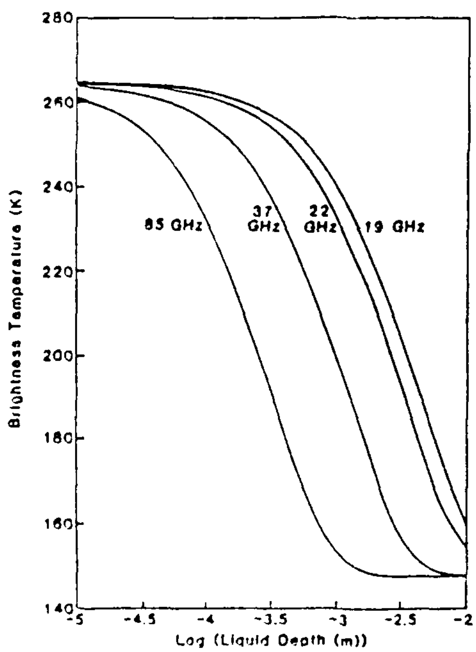
$$I = I_{ice} e^{-\tau_{water}} + S(T)(e^{-\tau_{water}} - 1)$$

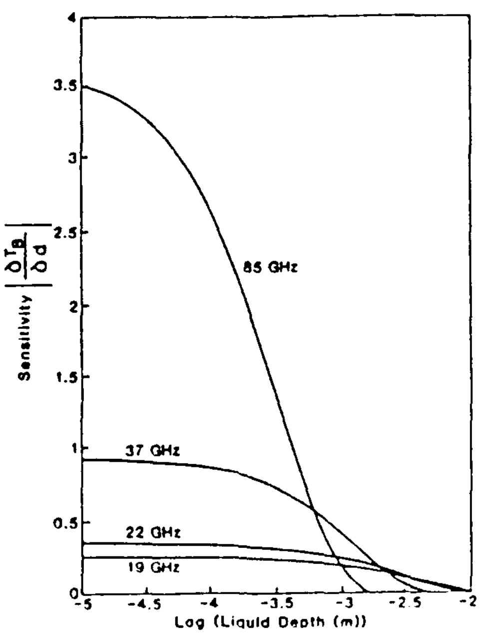
Source

$$S_\nu = \frac{2h\nu^3}{c^2(e^{\frac{h\nu}{kT}} - 1)}$$
$$\approx 2kT\left(\frac{\nu}{c}\right)^2$$

Flooded Ice in Arctic Regions

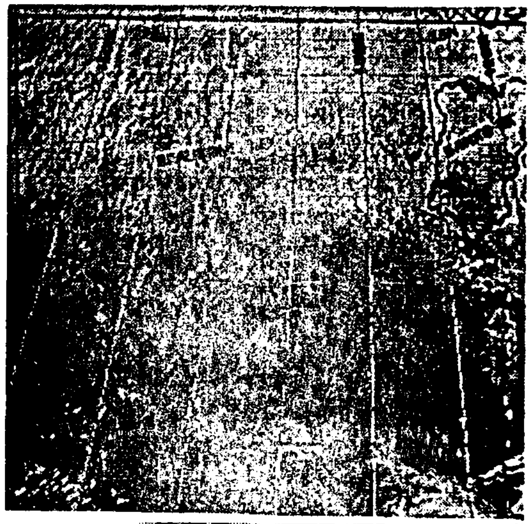
Frequency Dependence of Surface Emission





Flooded Ice in Arctic Regions

DMSP OLS, Fine, Visible, 1820 UTC



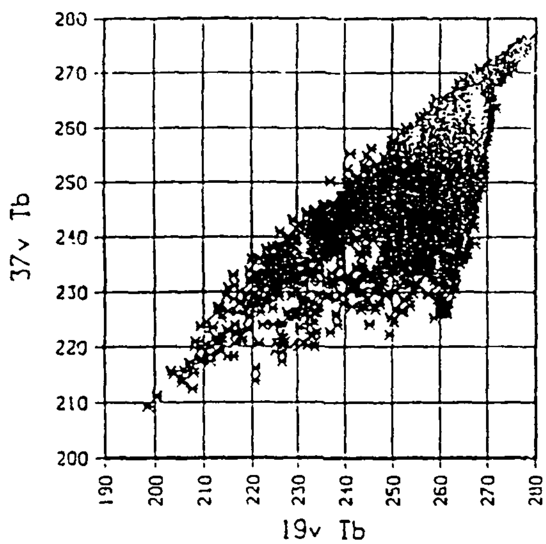
Flooded Ice in Arctic Regions

Sunglint pattern DMSP OLS 1536 UTC

Flooded Ice in Arctic Regions

SSM/I T_b over water, ice, and flooded ice

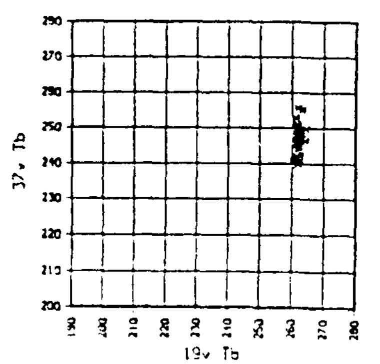
19v vs 37 v Brightness temperature



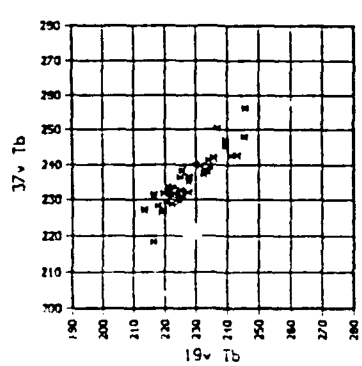
Flooded Ice in Arctic Regions

SSM/I Brightness Temperature Variations

19v vs 37 v Brightness temperature



19v vs 37 v Brightness temperature



Averaging Region: 1° × 1°

CLASSIFICATION-BASED RAINFALL ESTIMATES USING SATELLITE DATA AND NUMERICAL MODEL OUTPUT

Christopher Grassotti and Louis Garand

Atmospheric Environmental Service
2121 Trans-Canada Highway
Dorval, H9P 1J3
Canada

As part of ongoing efforts at AES to utilize satellite data within the Canadian Meteorological Center forecast and analysis system we have been exploring methods of retrieving rainfall at both short (hourly) and longer (monthly) timescales. It is anticipated that retrieved rain rates at hourly timescales may be incorporated within a diabatic initialization procedure at the start of each forecast run - hopefully reducing the "spin-up" problem.

The retrieval method to be presented uses an objective multifeature classification approach in which each analysis box (1.25° lat/lon) is classified based on a variety of features extracted from both visible and infrared imagery. Notably, we also use predicted fields of vertical motion from the operational forecast model as an additional feature. A class-dependent rain rate is then assigned to the analysis box. Preliminary results (GPCP) AIP-1 (Japan) have indicated that the addition of the model fields do improve estimates of rainfall compared with those obtained using a VIS/IR only approach. Currently, microwave observations are not used in the retrievals, however we do intend to include SSM/I measurements in application of this retrieval method to the GPCP AIP-2 (Great Britain) data set.

CLASSIFICATION-BASED RAINFALL ESTIMATES USING SATELLITE DATA AND NUMERICAL FORECAST MODEL OUTPUT

Christopher Grassotti and Louis Garand

Atmospheric Environment Service
Dorval, Quebec
CANADA

15 April 1992

OBJECTIVE: Improvement of rainfall estimation at synoptic and climate scales. Ultimately to be used within a diabatic initialization procedure at start of CMC operational forecast runs.

APPROACH: Combine information from both satellite (VIS/IR) <u>and</u> numerical model forecast fields. (presently no MW data used.)

TECHINIQUE: Multifeature classification using minimum distance criteria in feature space. Mean rain rate is assigned to each class.

DATA SET: The GPCP first AIP observing period (June, July/Aug. '89).

1. CLASSIFICATION

•Initial Clustering: establish most useful features/classes. Use the minimum squared error criterion (Duda and Hart, 1973).

$$J_e=\sum_{i=1}^{c} J_i$$

$$J_i= \sum_{x\in X_i} (x-m_i)^2$$

Move sample from class i to j if J_i decreases more than J_j increases.

•Classification: place sample in class for which metric distance to class mean is minimized.

2. DATA SETS

June-August 1989, GPCP AIP 1 over Japan. Data available hourly at 1.25° lat/lon.

(1) AMeDAS Network: Rain gauge/Radar composites

(2) VIS/IR imagery from GMS. Analyzed using technique of Garand (1988) to obtain AL,TT,CF at 1.25°.

(3) Model forecast fields of rain rate interpolated to same grid. Model is CMC global spectral (T106, Kuo convection).Sequence of model 6 hr forecasts, initialized every 6 hours were interpolated to intermediate hours permitting estimation at every hour.

3. RETRIEVALS (June)

•Daytime: 3 Feat., 30 Classes (TT,AL,RR_f).

•Nighttime: 3 Feat., 30 Classes (TT,CF,RR_f).

•Decision tree:

(1)All CF < 96 %, RR=0.

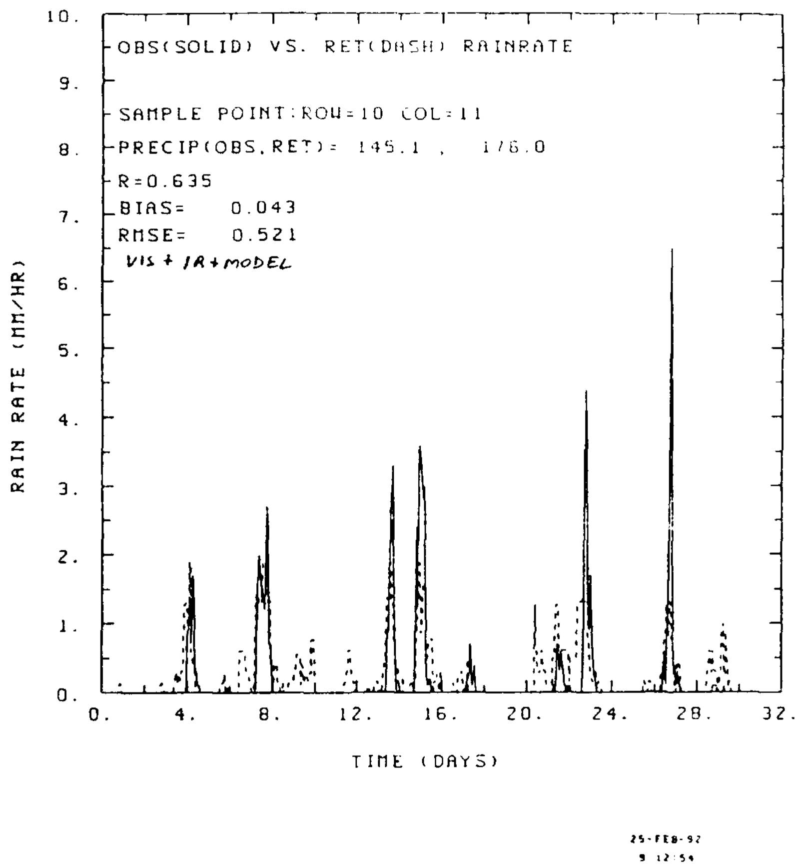
(2)IR temp screening:
TT<210 K, RR=5.7 mm/h
TT<220 K, RR=4.3 mm/h

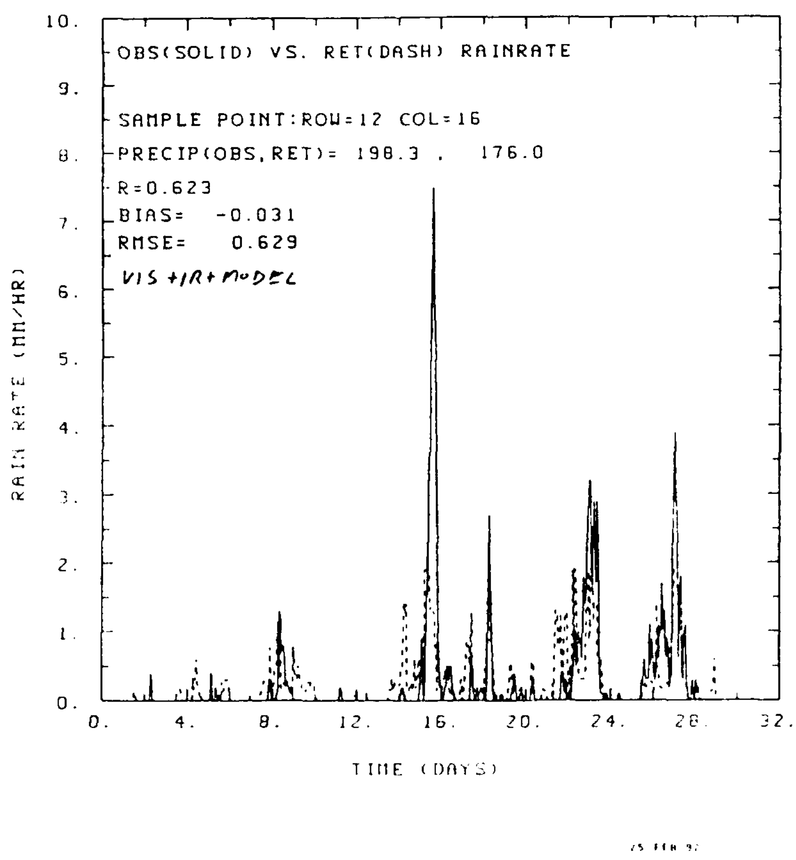
(3)Classification
Classify 1.25°x1.25° box.
Assign mean RR of class.

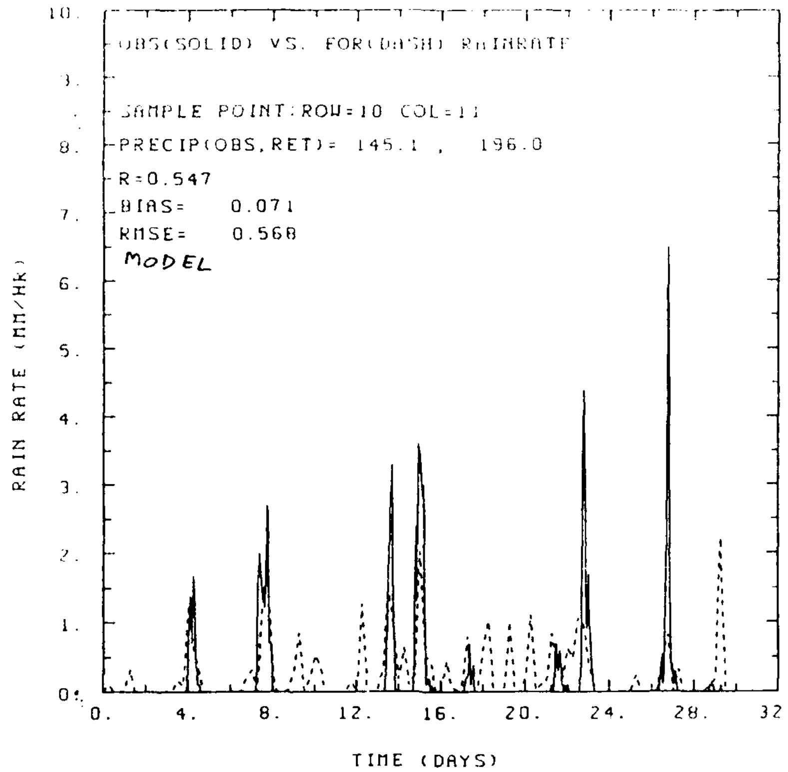
•Application:
Dependent set=first and last 7.5 days of June.
Semi-independent set=entire month.

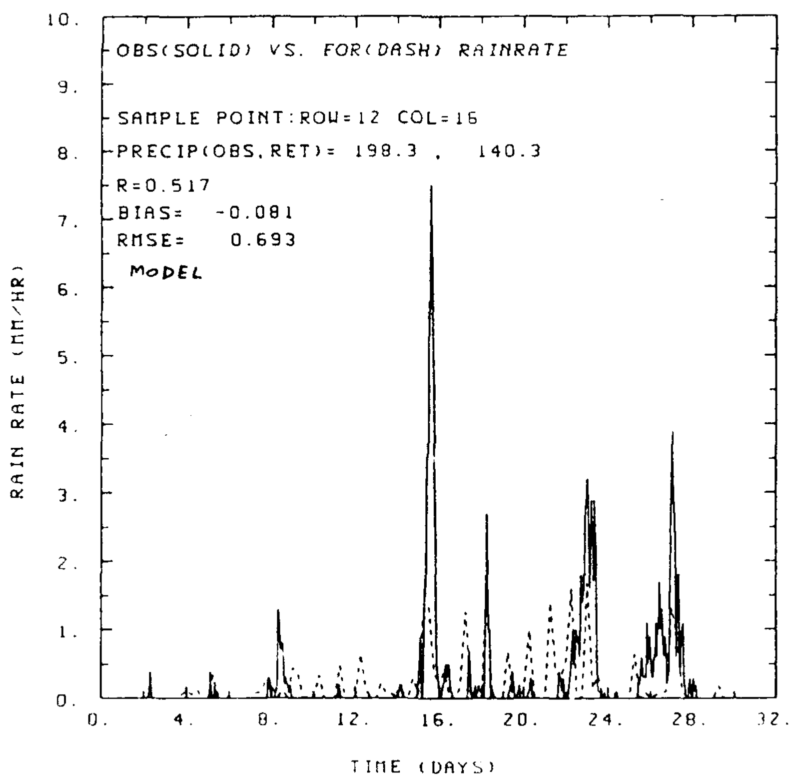
RAIN RATE RETRIEVAL ERRORS

Month	Method	Monthly (mm)			Hourly (mm/h)		
		R	RMS	BIAS	R	RMS	BIAS
June	VIS+IR+Model, 30 cl.	.846	53.0	1.8	.621	.604	-.001
	VIS+IR+Model, 20 cl.	.839	54.3	0.1	.611	.611	-.004
	Model	.806	56.9	-15.4	.541	.649	-.027
	VIS+IR	.740	67.2	11.2	469	.681	.012
	IR	.628	73.5	1.6	.410	.703	-.002
July/ Aug	VIS+IR+Model (June)	.730	95.1	-46.0	.490	.615	-.071
	VIS+IR+Model	.680	84.1	-16.6	.535	.592	-.028
	Model	.481	92.3	-11.1	.188	.740	-.018
	VIS+IR	.610	88.1	-18.9	.538	.591	-.031

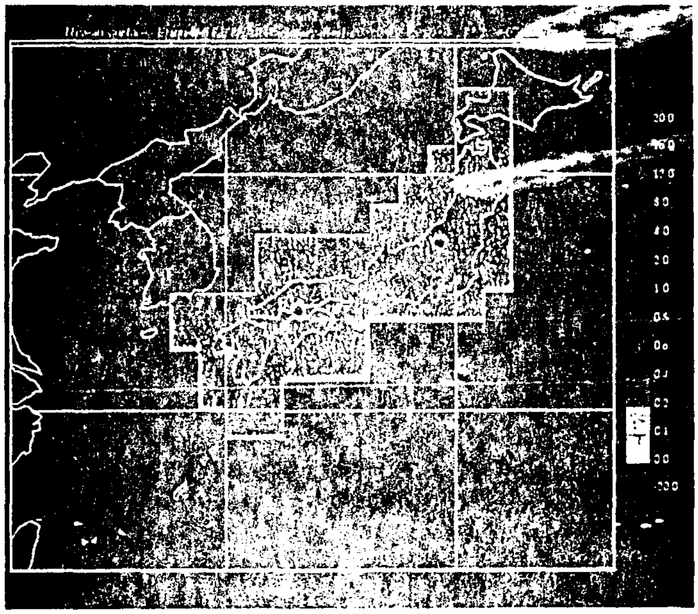

OBS(SOLID) VS. RET(DASH) RAINRATE
SAMPLE POINT:ROW=10 COL=11
PRECIP(OBS,RET)= 145.1 , 176.0
R=0.635
BIAS= 0.043
RMSE= 0.521
VIS + IR + MODEL
RAIN RATE (MM/HR)
TIME (DAYS)
25-FEB-92


OBS(SOLID) VS. RET(DASH) RAINRATE
SAMPLE POINT:ROW=12 COL=16
PRECIP(OBS,RET)= 198.3 , 176.0
R=0.623
BIAS= -0.031
RMSE= 0.629
VIS + IR + MODEL
RAIN RATE (MM/HR)
TIME (DAYS)

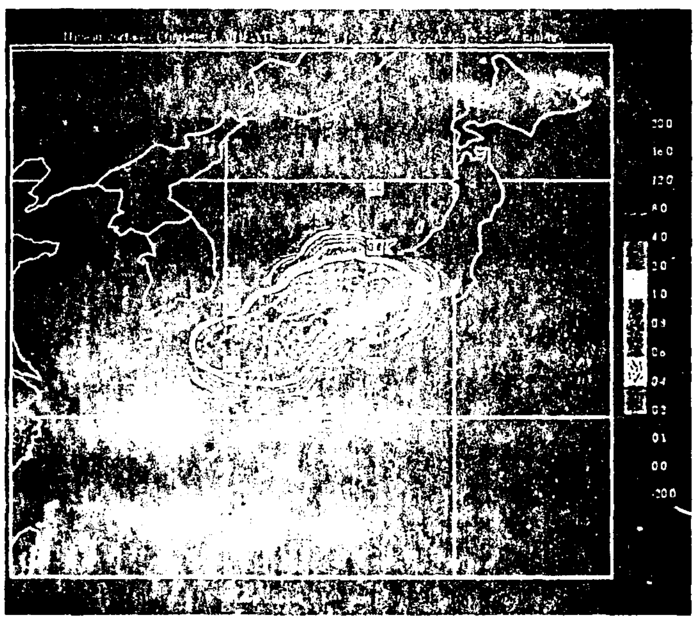

OBS(SOLID) VS. FOR(DASH) RAINRATE
SAMPLE POINT:ROW=10 COL=11
PRECIP(OBS,RET)= 145.1 , 196.0
R=0.547
BIAS= 0.071
RMSE= 0.568
MODEL
RAIN RATE (MM/HR)
TIME (DAYS)
13-FEB-97
9:41:59


OBS(SOLID) VS. FOR(DASH) RAINRATE
SAMPLE POINT:ROW=12 COL=16
PRECIP(OBS,RET)= 198.3 , 140.3
R=0.517
BIAS= -0.081
RMSE= 0.693
MODEL
RAIN RATE (MM/HR)
TIME (DAYS)

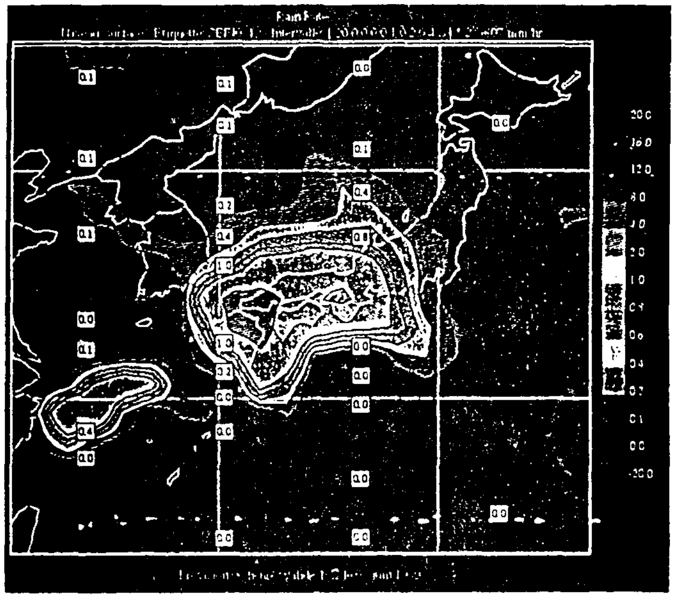
Data Mask



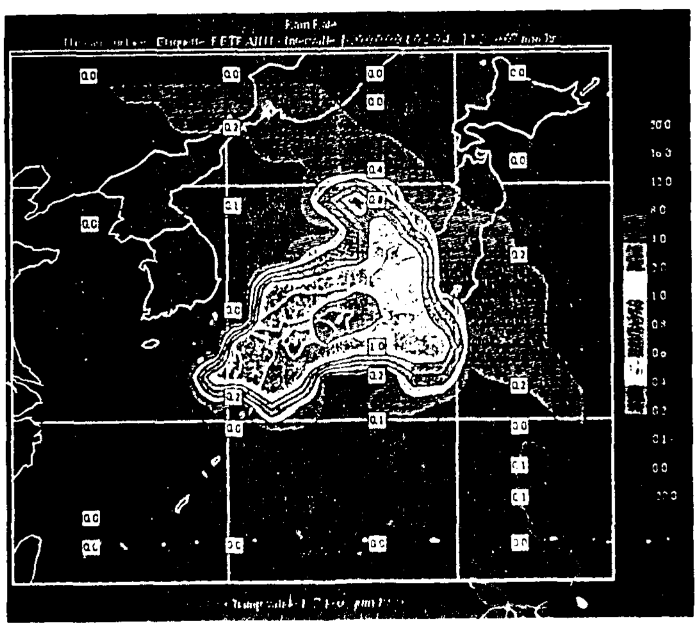
Observed RR   8 june 89 18Z



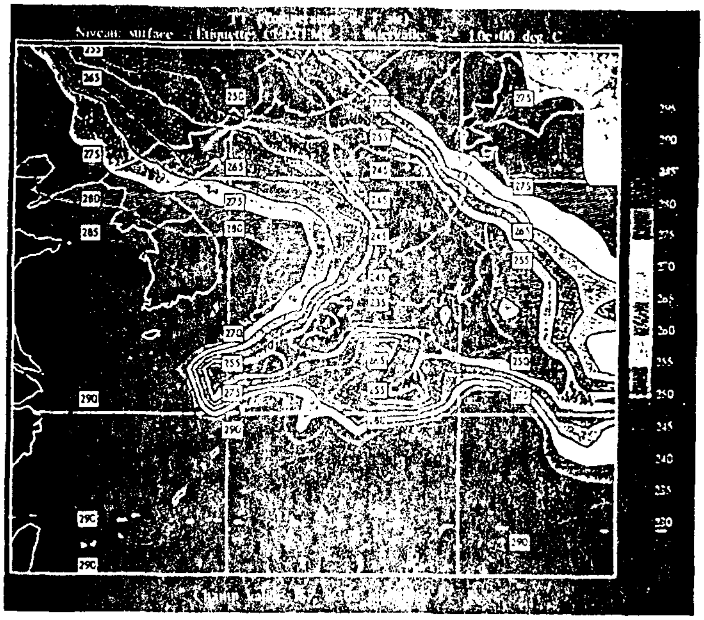
6 hr forecast RR 8 june 89 18z



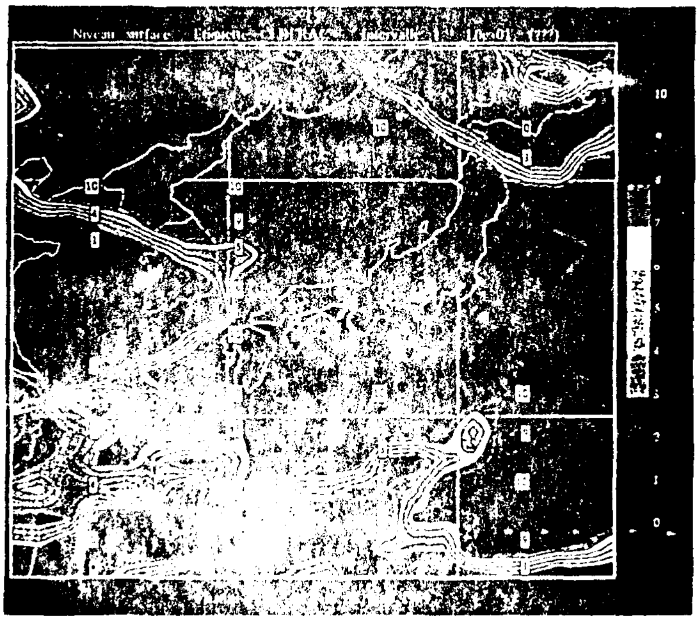
Retrieved RR 8 june 89 18z



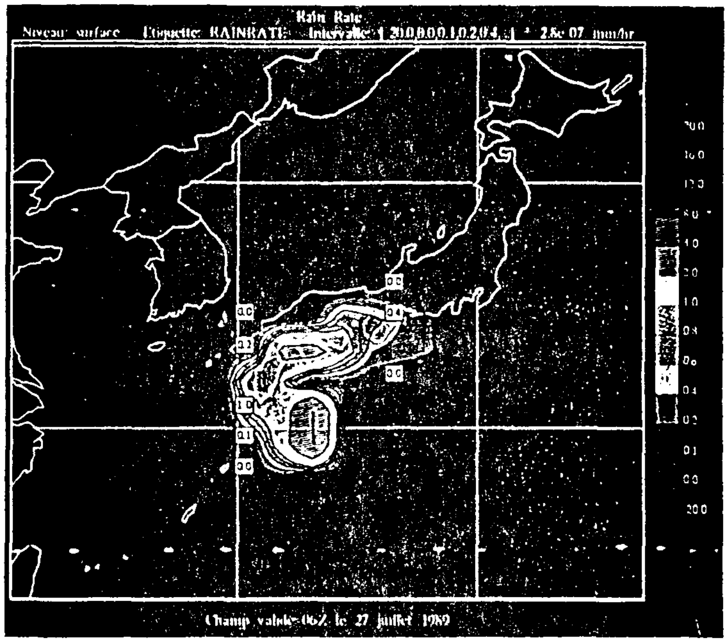
Observed CTT 8 june 89 18z



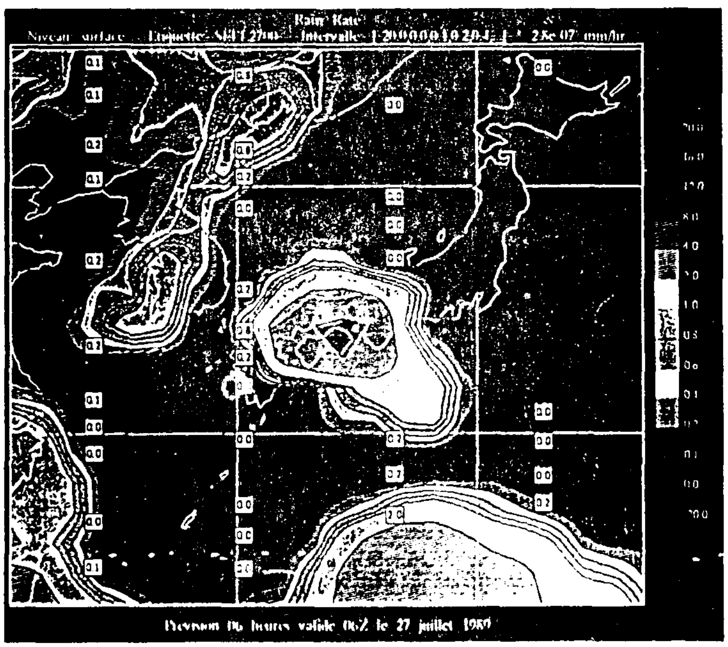
Observed CF 8 june 89 18z



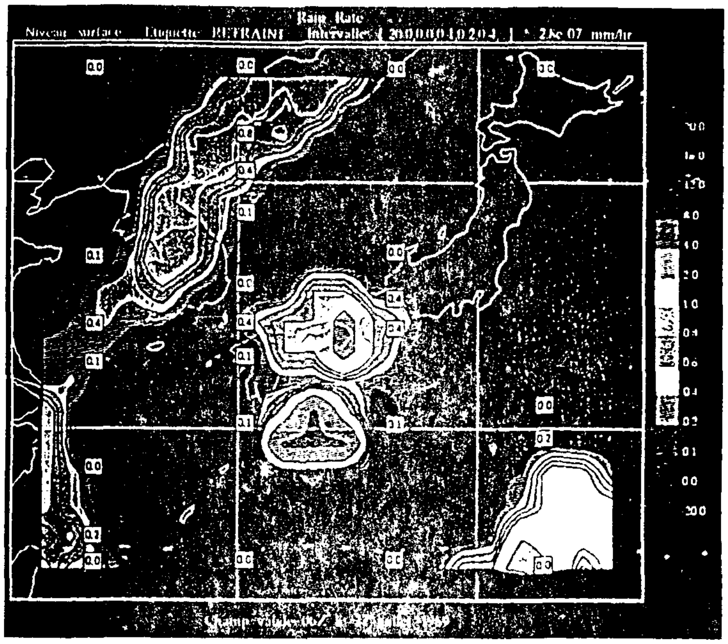
Observed RR 27 july 89 6Z



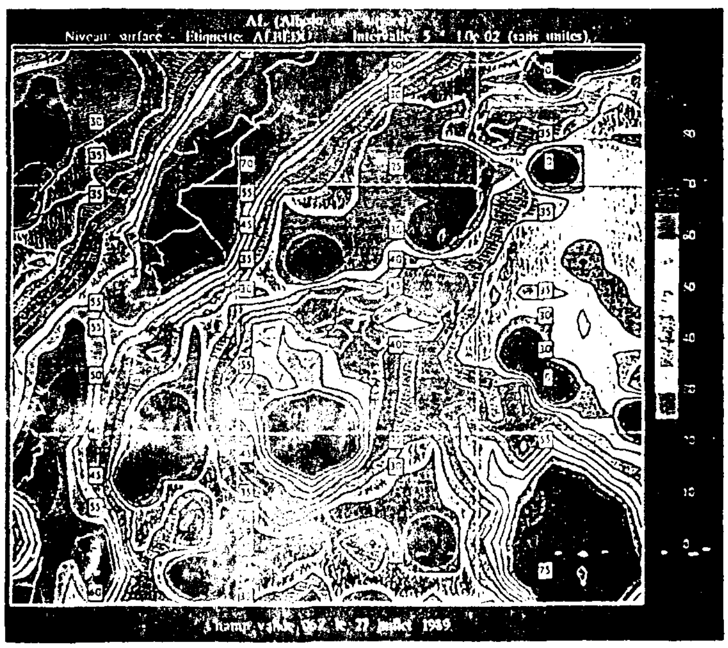
6 hr forecast RR 27 july 89 6Z



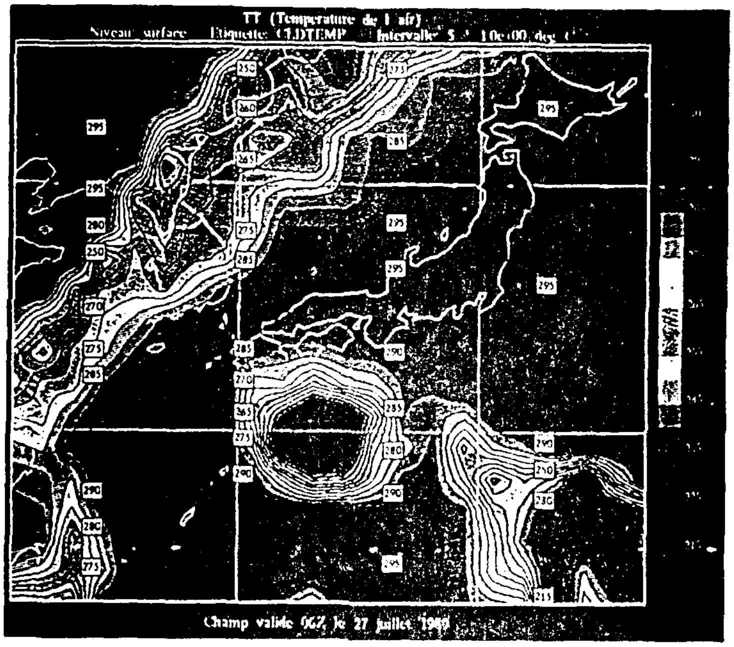
Retrieved RR 27 july 89 6Z



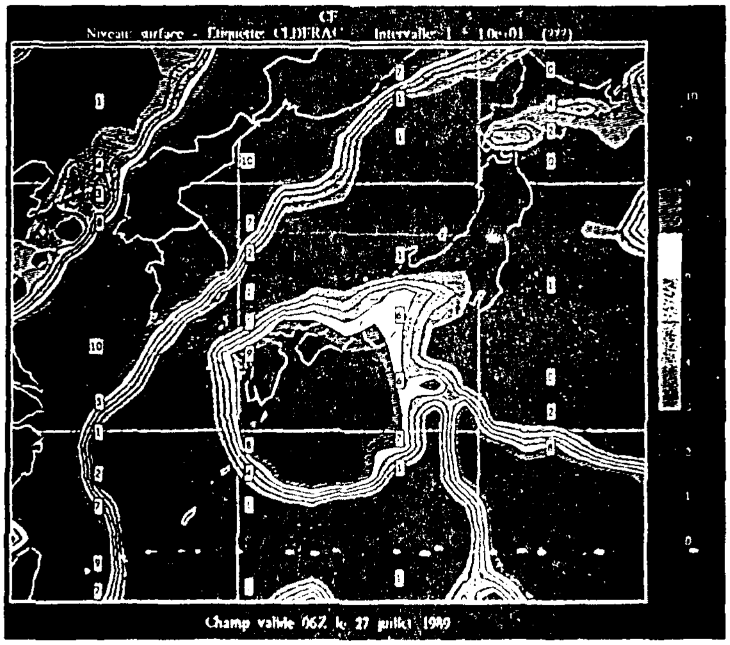
Observed AL 27 july 89 6Z



Observed CTT 27 july 89 6Z



Observed CF 27 july 89 6Z



4. CONCLUSIONS

- By combining model forecast estimates with geostationary satellite data, we improve estimates of rainfall at hourly and monthly time scales over estimates obtained from either satellite or model alone.

- Method needs more testing and validation to resolve issues of dependence on regional climate and rainfall regime. e.g. validity over midlatitude stratiform precipitation unknown. (GPCP-2,Gr. Britain).

- Approach can easily accomodate additional features/predictors (SSM/I, cloud texture, etc.)

THE INFLUENCE OF CLOUD MICROPHYSICAL STRUCTURE ON SPACEBORNE MULTISPECTRAL MICROWAVE OBSERVATIONS

Irene G. Rubenstein

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Institute for Space and Terrestrial Science
4850 Keele Street, North York
Ontario, Canada M3J 3K1

The evolution of microwave radiative properties of precipitating clouds is explored in this study. Numerical simulation of hydrometeor effects, utilizing realistic atmospheric profiles and cloud microphysical structure, on the upwelling microwave radiation is evaluated. The effects of ice hydrometeors and melting layer presence have been considered. The top of the atmosphere brightness temperatures at several frequencies are computed by means of radiative transfer model for the surface backgrounds of ice free, rough ocean and low sea ice concentrations. The sensitivity of the calculated brightness temperature to uncertainties of the input environmental parameters is evaluated for test scenarios from Labrador Ice Margin Experiment (LIMEX) and other documented oceanographic research campaigns. Results of a retrieval procedure developed utilizing the simulation results appear to be in qualitative agreement with the available surface observations.

The Influence of Cloud Microphysical Properties on Spaceborne Multispectral Observations.

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Abstract

The use of spaceborne microwave radiometry to study physical properties of the Earth's surface and atmosphere became possible since the launch of COSMOS-243 (Basharinov 1971). Since 1978 multispectral microwave radiance measurements are used for monitoring of surface and atmospheric parameters (Davies et.al 1989 Ramseier et. al 1988.) The retrieval of oceanographic and atmospheric parameters from spaceborne multispectral measurements are guided by the results obtained from radiative transfer modelling and a-priori statistics. This type of information can be used as a input to the atmospheric models used in weather forecasting and air mass transport models. At this, stage the theoretical results of cloud extinction coefficients and top-of-the atmosphere brightness temperatures calculated using model clouds will be evaluated for their use to provide guidance in retrieval algorithms. In this research project we evaluate techniques used to identify presence of the liquid water and cloud ice effects.

The evolution of microwave radiative properties of precipitating clouds is explored in this study. Numerical simulation of hydrometeor effects, utilizing realistic atmospheric profiles and cloud microphysical structure, on the upwelling microwave radiation is evaluated. The effects of ice hydrometeors and melting layer presence have been considered. The top of the atmosphere brightness temperatures at several frequencies are computed by means of radiative transfer model for the surface backgrounds of ice free, rough ocean and low sea ice concentrations. The sensitivity of the calculated brightness temperature to uncertainties of the input environmental parameters is evaluated for test scenarios from Labrador Ice Margin Experiment (LIMEX) and other documented oceanographic research campaigns. Results of a retrieval procedure developed utilizing the simulation results appear to be in qualitative agreement with the available surface observations.

SSM/I observations for selected events were analysed using the theoretical results of Mugnai and Smith (1988) and Curry (1991)
Results of numerical simulations of hydrometeor effects, utilizing realistic atmospheric profiles and cloud microphysical structure, on the upwelling microwave radiation are evaluated in this study. The top-of-the atmosphere brightness temperatures calculated for the ice-free ocean surface backgrounds and low ice concentration (marginal ice zone) scenarios are compared with the Special Scanning Microwave Imager measurements

1 Introduction

With the increasing use of satellite remote sensing for monitoring o atmospheric and surface meteorological parameters, the interpretation of remote sensing observations is a top priority task. A number of simulation and airborne studies have been carried out in an attempt to explore the accuracy of passive microwave measurements in providing meteorological information, . Spaceborne passive microwave remote sensing for the monitoring of the polar ocean surface is now used routinely. In currently used ocean surface wind speed and sea ice cover parameter retrieval algorithms, influence of the atmospheric conditions is given a *very simple minded treatment*. Severe winter storms affect the ice boundaries and introduce uncertainties into ice type identification. These effects can be approximated if the sea ice information is needed as a weekly or a monthly averaged parameter, but require more complex treatment for near-real time use of data. Use of cloud radiative properties to provide more reliable atmospheric information will allow for more accurate description of the ocean surface parameters, as well as allow simultaneous retrieval of precipitation information for ice free areas.

In order to establish the dependence of brightness temperature on cloud water content, cloud type and precipitation, high resolution airborne observations collected during the COoperative Huntsville Meteorological EXperiment (COHMEX) (Dodge et al.1986), were analyzed . The airborne passive microwave data for several storm scenarios were acquired over land (see for example Figure 1) but the effect of different cloud particles on the upwelling brightness temperatures can be translated for use over the ocean. This information supplemented with simulation studies using radiative transfer model for calculation of the upwelling microwave radiance at various frequencies for specified hydrometeor profile (Mugnai and Smith, 1988; Smith and Mugnai, 1988; Rubinstein 1992) was used to evaluate the spaceborne passive microwave observations for a number of selected storm events. Currently, an algorithm for retrieval of ocean surface information and atmospheric parameteres, utilizing 19 and 37 GHz SSM/I brightness temperatures, is used operationally. Model brightness temperatures (Wentz, 1983) were used in uncoupling atmospheric and surface information. The objective of this study is to evaluate the use of results of *radiative transfer simulations for the frequencies* used in this algorithm and 85 GHz in providing information not only about precipitation, but about cloud microphysical structure as well.

2 Cloud radiative models.

The microwave absorption spectrum of atmospheric gases has been investigated in-depth both theoretically and experimentally (Waters 1976, Ulaby et.al 1981). In the microwave region absorption by water vapour and molecular oxygen dominate the extinction process. Microwave emission from the atmosphere represents the result of complex interactions between microwave radiation emitted from the surface and the atmosphere with its ongoing extinction through interactions with the atmospheric constituents. Interpretation of the measured radiances, as they relate to cloud microphysical structure, is not straightforward. Similar brightness temperatures for single observational frequency may result from a variety of atmospheric conditions (Figure 2). The effect of water and ice clouds on upwelling microwave radiation can be approximated by considering their bulk transmitance properties. Extinction coefficients and single particle scattering albedo, parameters used in calculating brightness temperatures reaching satellite sensors, are calculated using Mie approximation

(Figures 3,4,5). Clouds are assumed to contain liquid and ice hydrometeors. The amounts of each type of hydrometeors drop size distribution, cloud top temperatures are introduced into these calculations either as known or cloud models are used to describe evolution of atmospheric conditions. The top of the atmosphere spaceborne measurements of brightness temperature at 19, 22 and 37 GHz have been utilized since 1976 (Grody 1976, Wu and Weinman 1984, Wilheit 1986; Davies et. al 1990) for remote sensing of atmospheric liquid water and water vapour. Coupling of cloud models to the microwave radiative transfer models (Smith and Mugnai 1988) allows evaluation of the effects of the vertical distribution of hydrometeor types on the upwelling microwave radiation.

3 Results

The evaluation of the performance of the atmospheric influence on the ocean surface parameter retrievals indicates that not only the sensitivity to heavy clouds and precipitation has to be taken into account within the algorithm, but to the presence of dense fog as well, especially in the low ice concentation areas (Ramseier et al. 1991) . The statistical evaluation of the uncertainty of the ocean surface retrievals as a function of different evolution stages of precipitating clouds is our next objective . The overall impact of water and ice clouds on upweling microwave radiation can be approximated by considering their bulk transmittance properties. Clouds form at altitudes where absorption of microwave radiation by water vapor and oxygen can be considerable. The transmission and emission of microwave radiation by individual layers of a cloud has to be evaluated. In addition, one must take into account the radiation emitted and reflected by the surface.

This study is done in two stages. In part one of this study we utilize 19, 22, 37, 85 GHz frequencies of the Special Scanning Microwave Imager. The numerical calculations, utilizing cloud microphysics, of expected top of the atmosphere brightness temperatures, were compared with brightness temperatures measured during selected events. The analysis of data indicates that the flagging of an onset of precipitation can be done using 19 and 37 GHz channels (Figures 6,7,8). The additional information about the presence of ice particles within the precipitating clouds is provided by considering the difference between 19 and 85 GHz brightness temperatures. At this stage, data were analysed for their sensitivity to different atmospheric conditions. Examples of some of the study cases are shown in Figures 6 to 9. The results are in a agreement with observations by Curry (1991) and simulation predictions by Smith and Mugnai and others. Testing of algorithms utilizing these results is in progress.

4 Conclusion.

Microwave emission from a precipitating cloud top represents the result of a complex interaction between emitted microwave radiation and its extinction by the cloud liquid, melting phase and ice hydrometeors. The microwave brightness temperatures at 85 GHz contain information on the scattering properties of the clouds, supplementing the use of 37 and 19 GHz, already utilized for retrieval of integrated water vapour and liquid water amounts. The existing algorithm for the retrieval of the water vapour, liquid water and precipitation will be modified to include more accurate cloud structure information. Atmospheric and satellite data collected during CASP II will be used for testing of the modified algorithms.

The use of the passive microwave data by meteorologists and climatologists and their confidence in accuracy of the retrieval algorithm performace will increase once these tasks are completed. Remote sounding of atmospheric parameters from meteorological satellites has made a significant impact on weather forecasting and our understanding of large-scale circulation patterns. The derivation procedures for quantitative estimates of vertical cloud composition and structure can now be tested with actual data.

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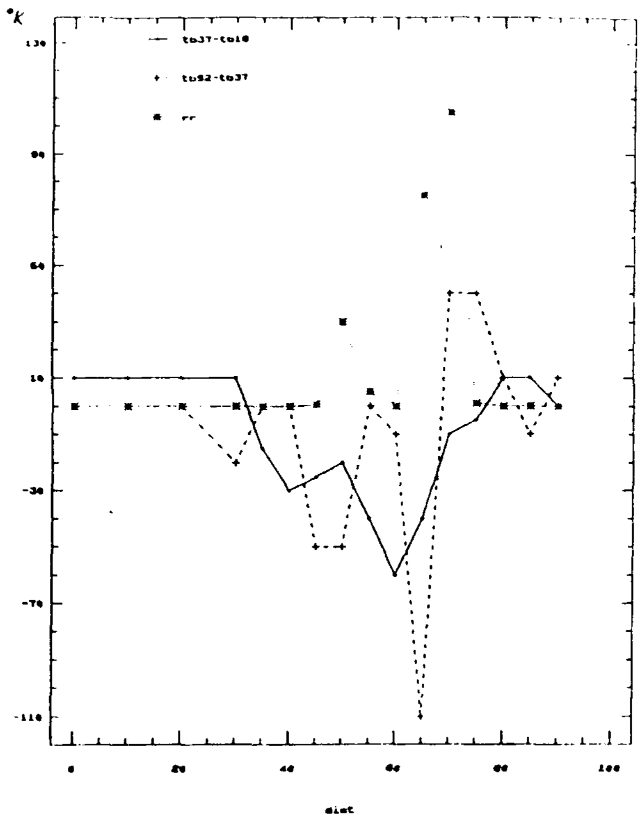
CONMEX, JULY 11, 1986

FULTON & HEYMSFIELD, J.APPL.MET.1991,JAN



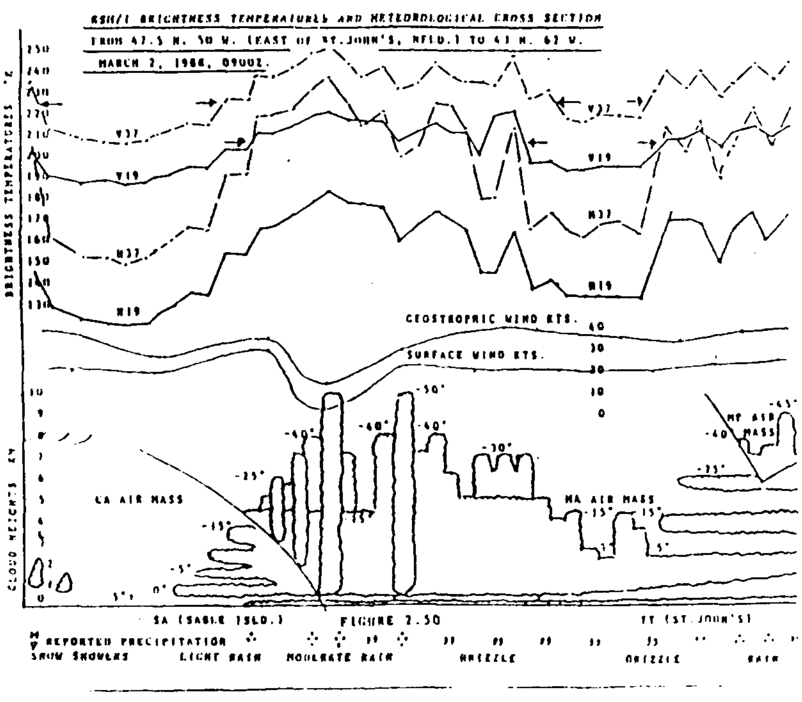
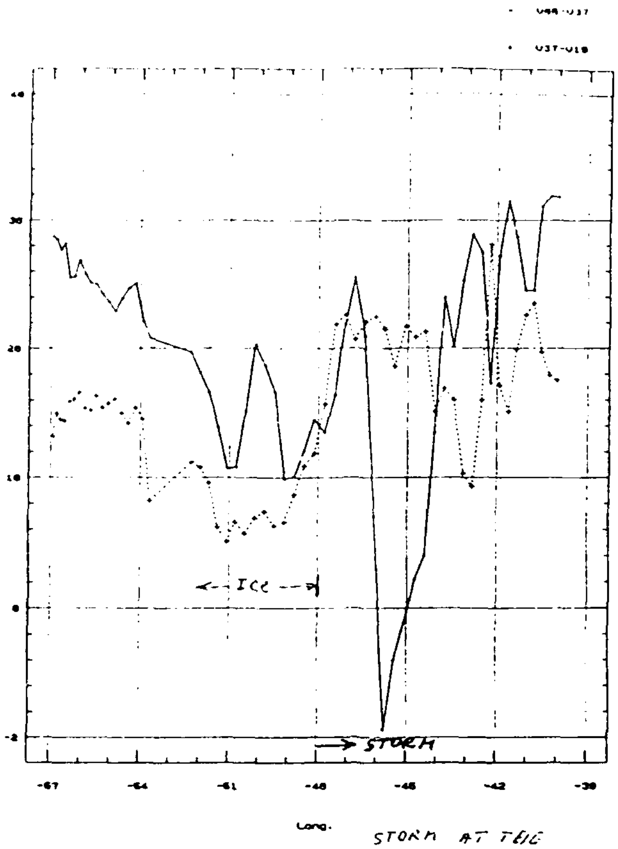


FIGURE 2.50



STORM AT THE ICE EDGE Feb '92

Fig 2b

EXTINCTION COEFFICIENTS; ICE PARTICLES
(KUMMEROW & WEINMAN, IEEE GE-26,1988)

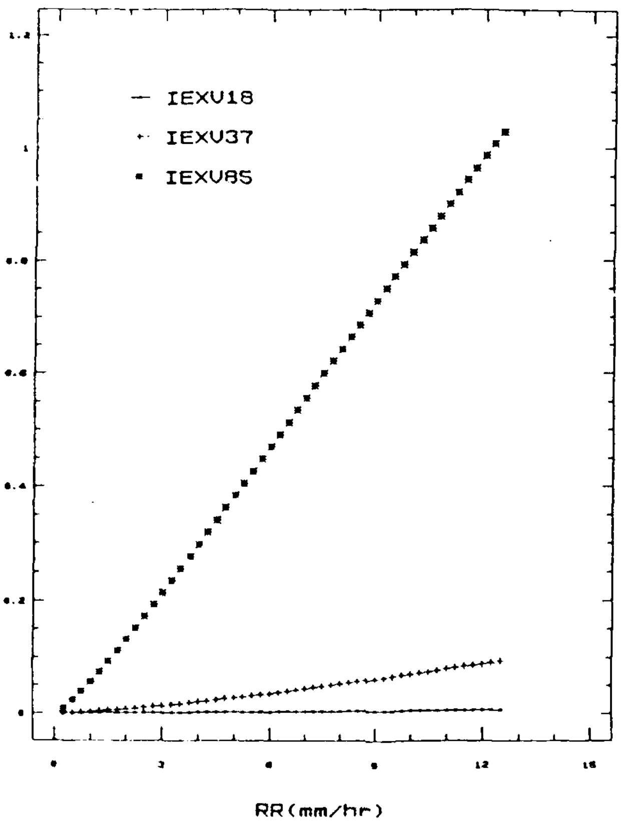


Fig 3

EXTINCTION COEFFICIENTS; LIQUID at 20C

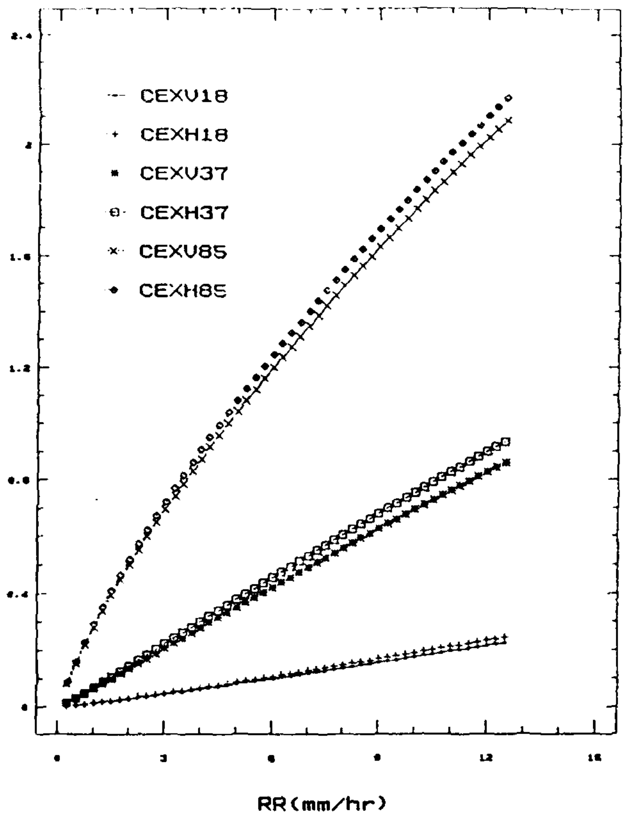


Fig 4

ALBEDO

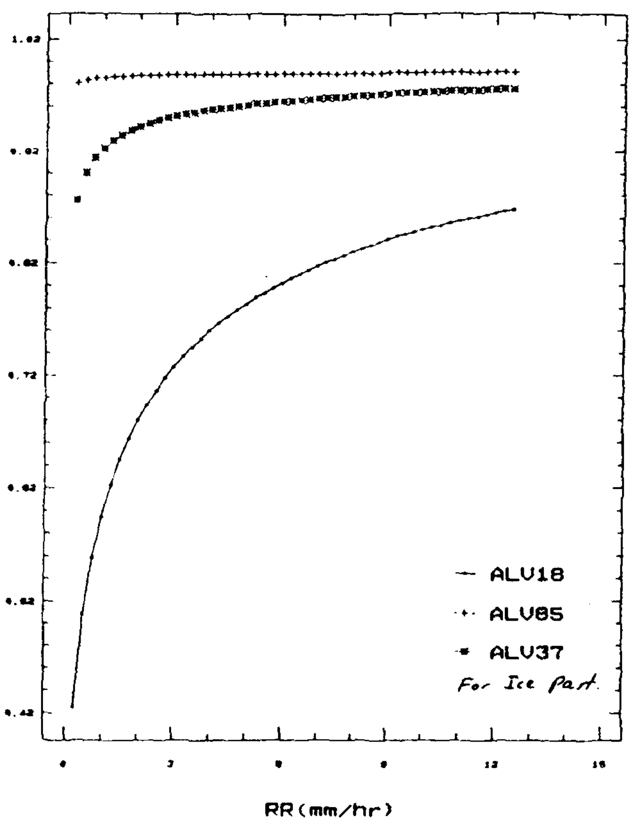
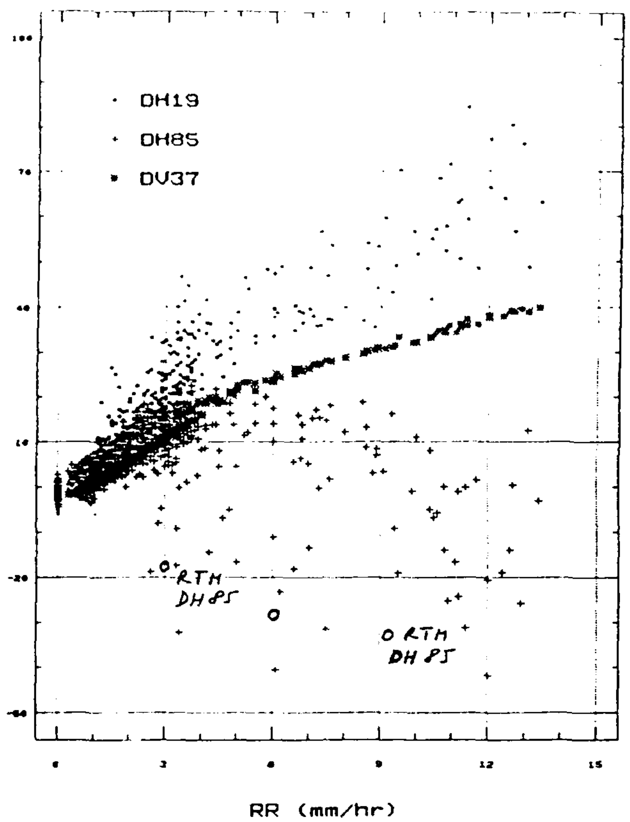


Fig 5

TROPICAL STORM 011636 SEPT. 20/89



RR = A·V37 + B·H37 + C
(RTH; RUBINSTEIN '92)

FIG 6a

HUGO SEP. 20/89
WIND CORRECTED H85 AND H19

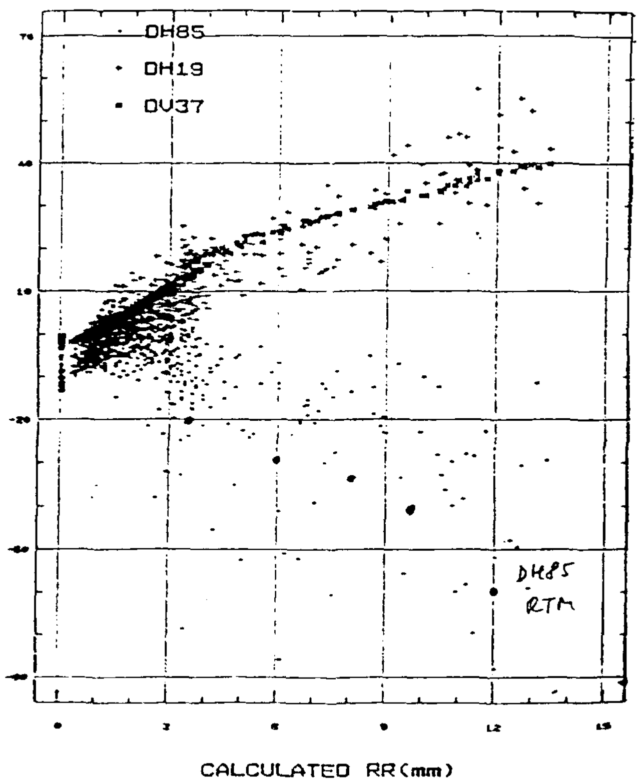
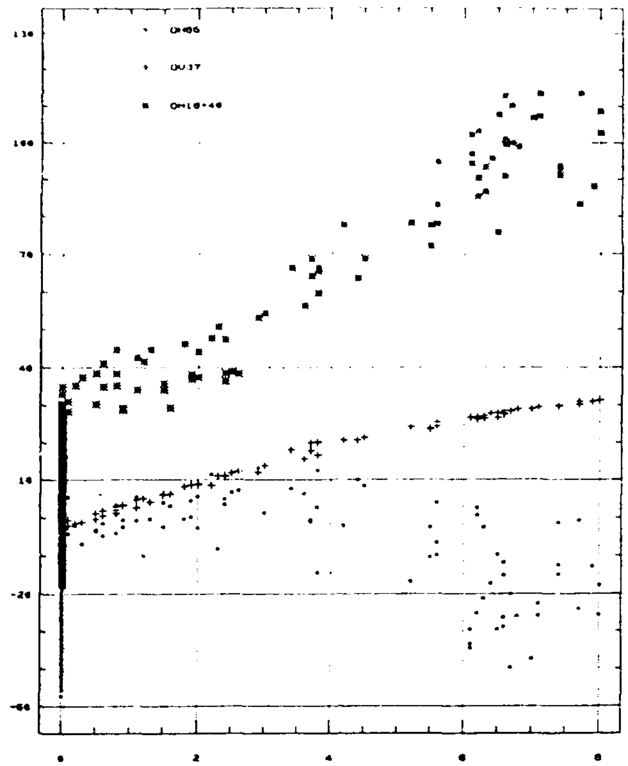
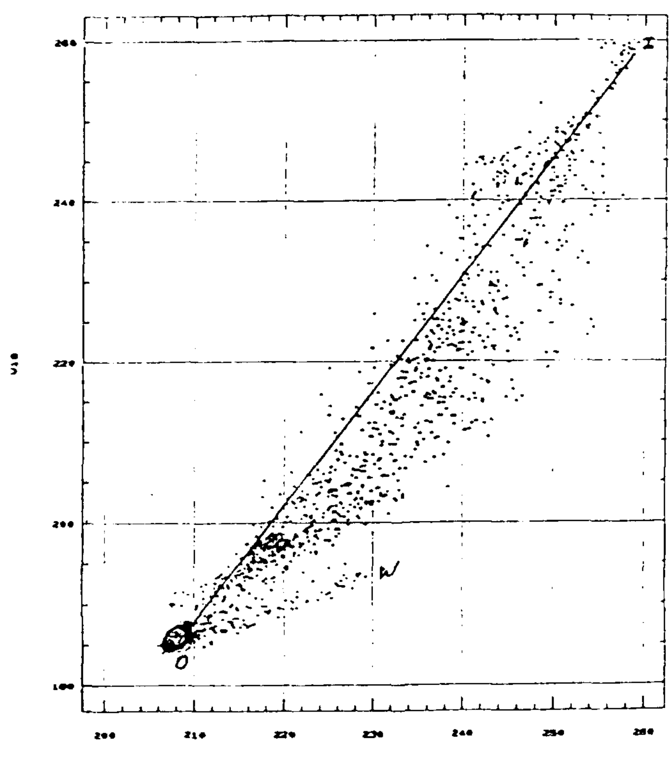


Fig 6b

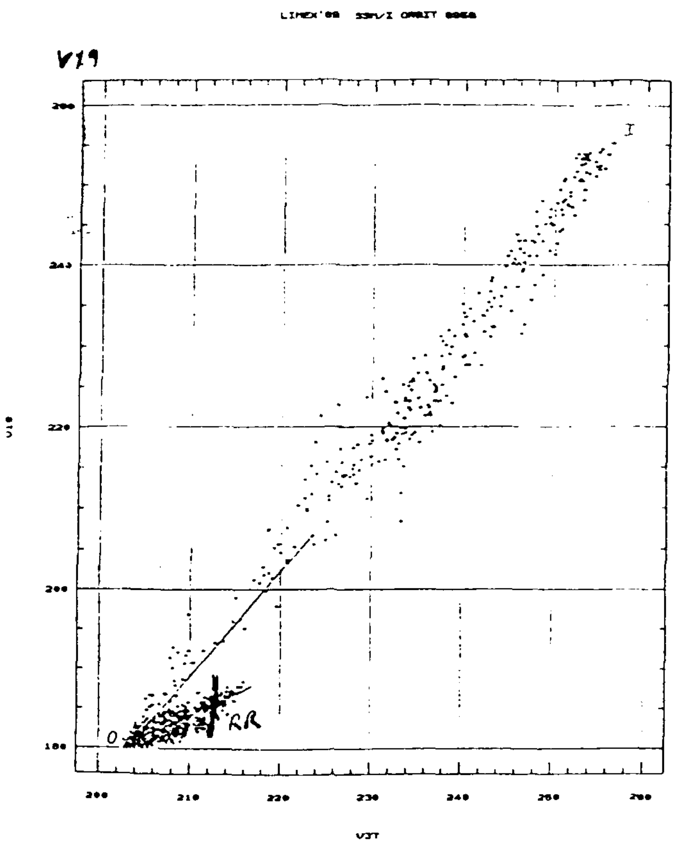


South of 46°N

Fig 7



STORM EFFECT
ON SEA ICE SIGNATURES
Fig 9



OI - ICE

OCEAN + WEATHER

Fig 8

APPENDIX

ATMOSPHERIC AND ENVIRONMENTAL RESEARCH, INC.

Subject: ***NMC/NESDIS/DoD Workshop on DMSP Retrieval Products***

Dear Colleague:

A recurring theme at recent satellite meteorology and numerical weather prediction symposia has been the availability and relevance of products derived from the Defense Meteorological Satellite Program (DMSP) sensors, particularly the SSM/T and SSM/I products. As real time access to these data has been improved through the Shared Processing efforts of both the Department of Defense (DoD) and NOAA's National Environmental Satellite, Data, and Information Service (NESDIS), the scientific community's interest in the use of these data has increased.

In response to this interest, a *Workshop on DMSP Retrieval Products* has been planned by scientists at the NOAA/ National Meteorological Center (NMC), NOAA/NESDIS, and the DoD. The objective of the workshop is to bring together individuals from both the defense and civilian communities with a common goal of understanding the use of DMSP retrieval products. The format will consist of contributed papers and sufficient time for discussions. It is hoped that this interaction will benefit all concerned. The workshop will be organized by Atmospheric and Environmental Research, Inc. (AER).

The *Workshop on DMSP Retrieval Products* will be held 14-15 April 1992 at the NOAA Science Center in Washington, DC. A tentative agenda is attached. You are invited to contribute a 15 minute presentation describing your recent DMSP related work. Please submit a short abstract for inclusion in the proceedings of the meeting by 15 November. If you do not wish to present a paper but are interested in attending, please call or write to the workshop chairman (617-547-6207 or rgi@aer.com).

We look forward to your active participation.

Sincerely,

Ron Isaacs

Ron Isaacs
Workshop Chairman

Eugenia Kalnay

Eugenia Kalnay, NOAA/NMC

P. Krishna Rao

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Final Agenda

NMC/NESDIS/DOD CONFERENCE ON DMSP RETRIEVAL PRODUCTS
14-15 APRIL 1992

Ron Isaacs, AER, Inc.
Workshop Chairman

Eugenia Kalnay, NOAA/NMC
P. Krishna Rao, NOAA/NESDIS
Robert McClatchey, AF PL/GPA
Workshop Organizing Committee

Tuesday, 14 April

Morning:

8:15 **Opening Remarks:** Kalnay/Rao/McClatchey

8:30 Session 1 - **Overview of Current and Future DMSP Sensors and Products**
Session Chairman: Ron Isaacs, AER, Inc.

8:30-8:50 **"SSM/I: Status Report"**
J. Hollinger (Naval Research Laboratory)

8:50-9:10 **"Calibration/Validation of the DMSP Microwave Water Vapor Sounder (SSM/T-2)"**
V. Falcone, J. Morrissey, M. Griffin (Phillips Laboratory), D. Boucher and B. Thomas (The Aerospace Corporation), R. Isaacs and J. Pickle (Atmospheric and Environmental Research, Inc.)

9:10-9:30 **"Performance of DMSP Special Sensor Microwave Humidity Profiler (SSM/T-2): Preliminary Results"**
D. Boucher and B. Thomas (The Aerospace Corporation)

9:30-9:50 **"DMSP Block 6: A Data Driven Approach"**
M.W. Borden, F. Kelly, G. Mandt (HQ, Air Force Systems Division), D.L. Glackin and J. Bohlson (The Aerospace Corporation)

9:50 Session 2 - **Operational and Quasi-Operational Retrieval Approaches and Products**
Session Chairman: R. McClatchey, Air Force Phillips Lab, Geophysics Directorate (GPAS)

9:50-10:10 **"NOAA/NESDIS Operational SSM/T Products and Distribution"**
E. Burdsall (NOAA/NESDIS)

10:10-10:25 **Break**

10:25-10:45 **"NOAA/NESDIS SSM/T Algorithms and Evaluation"**
T. Reale and D. Donahue (NOAA/NESDIS)

10:45-11:05 **"Defense Meteorological Satellite Program Microwave Radiometer Processing at Air Force Global Weather Central"**
T.J. Neu (HQ AFGWC)

Tuesday, 14 April

Morning:

Session 2 - **Operational and Quasi-Operational Retrieval Approaches and Products** (continued)

11:05-11:25 **"DMSP Special Sensor Microwave/Imager Processing at the Fleet Numerical Oceanography Center: Operational Status, Applications and Plans"**
M.C. Colton and C.J. Cornelius (Fleet Numerical Oceanography Center)

11:25-11:45 **"An Overview of the Experimental SSM/I Orbit-by-Orbit Products System (SSMIPROD) at NOAA/NESDIS"**
J. Fiore (S M Systems and Research Corporation)

Tuesday, 14 April

Afternoon:

1:00 Session 2 - **Operational and Quasi-Operational Retrieval Approaches and Products** (continued)

1:00-1:20 **"SSM/I Mapped Experimental Environmental Image Products"**
C. Boettcher (S M Systems and Research Corporation)

1:20-1:40 **"SSM/I Total Precipitable Water Vapor Algorithms: A Reprise and Update"**
J. Alishouse and R. Ferraro (NOAA/NESDIS)

1:40-2:00 **"The Use of the DMSP SSM/I for the Generation of Precipitation Products at NOAA/NESDIS: Part I: A Status Report"**
R. Ferraro and N. Grody (NOAA/NESDIS)

2:00-2:20 **"The Use of the DMSP SSM/I for the Generation of Precipitation Products at NOAA/NESDIS: Part II: Scientific Results"**
N. Grody and R. Ferraro (NOAA/NESDIS)

2:20-2:40 **"Production and Evaluation of Experimental SSM/I Ice and Wind Products at NOAA/NESDIS"**
W. Pichel (NOAA/NESDIS)

2:40-3:00 **"Real Time Quality Control of SSM/I Wind Speed Data"**
M. Waters, W.S. Richardson, W.H. Gemmill, and C.M. Caruso (NOAA)

3:00 **Break**

3:15-3:35 **"Status of NESDIS Distribution of SSM/I Products"**
P. Taylor (NOAA/NESDIS)

3:35-3:55 **"Processing and Distributing SSM/I Data via the Wet Net Project"**
H.M. Goodman (NASA Marshall Space Flight Center)

Tuesday, 14 April

Afternoon:

3:55 Session 3 - **New Retrieval Approaches and Products; Relevance to AMSU**
Session Chairman: George Ohring, NOAA/NESDIS

3:55-4:15 **"Joint NESDIS/NASA/NMC Effort to Develop an Advanced Satellite Retrieval System"**
W. Baker (NOAA)

4:15-4:35 **"Classification Retrieval Approaches for DMSP"**
L. McMillin (NOAA/NESDIS)

4:35-4:55 **"Using SSM/T Data as Proof of Concept for an AMSU-A Retrieval Algorithm"**
H. Fleming (NOAA/NESDIS) and E. Kratz (S M Systems & Research Corp.)

4:55-5:15 **"Temperature and Emissivity Results From a SSM/T Retrieval Algorithm"**
E. Kratz (S M Systems and Research Corporation) and
H. Fleming (NOAA/NESDIS)

Wednesday, 15 April

Morning:

Session 3 - **New Retrieval Approaches and Products; Relevance to AMSU** (continued)

8:30-8:50 **"Painless Extraction: Subtractive Temperature Sensing from Satellite Radiances Using the Zeta Transform"**
J. King (Phillips Laboratory, Geophysics Directorate)

8:50-9:10 **"SSM/I Measurements as Predictors of the Response of AMSU-A to Surface and Atmospheric Phenomena"**
P. Rosenkranz (Massachusetts Institute of Technology)

9:10 Session 4 - **Applications to Numerical Weather Prediction**
Session Chairman: E. Kalnay, NOAA/NMC

9:10-9:30 **"The Assimilation of DMSP Retrieval Products Into the Navy's Atmospheric Prediction Systems"**
J. Goerss and P. Pheobus (NOARL)

9:30-9:50 **"Impact of SSM/I-based Snow/ice Analyses in NMC's Eta Model"**
K. Mitchell and T. Black (NMC); F. Messinger (NOAA/NWS); N. Grody (NOAA/NESDIS)

9:50-10:10 **"Use of SSM/I Wind Speed Data in the Operational Numerical Weather Prediction System at NMC"**
T. W. Yu, W. H. Gemmill and J. Woollen (NMC)

10:10 **Break**

Wednesday, 15 April

Morning:

Session 4 - **Applications to Numerical Weather Prediction** (continued)

10:25-10:45 **"Comparison Between SSM/I and ECMWF Total Precipitable Water"**
L. Phalippou (ECMWF)

10:45-11:05 **"Meteorological Impact of Surface Wind Directions Measured by Over-the-Horizon Radar (OTHR) and Wind Speeds Measured by the SSM/I Microwave Radiometer"**
R. Atlas (NASA Goddard Space Flight Center), T.M. Georges (NOAA/Environmental Research Laboratory), and J.A. Weinman (NASA Goddard Space Flight Center)

11:05-11:25 **"Observations of Flooded Ice in Arctic Regions"**
A. Goroch and R. Fett (NOARL)

11:25-11:45 **"Classification-Based Rainfall Estimates Using Satellite Data and Numerical Forecast Model Output"**
C. Grassotti and L. Garand (Atmospheric Environmental Service)

11:45-12:05 **"The Influence of Cloud Microphysical Structure on Spaceborne Multispectral Microwave Observations"**
I. Rubenstein (Institute for Space and Terrestrial Science)

Afternoon:

1:15 Session 5 - **Open Discussion** *(issues, concerns, etc.)*

2:00 Session 6 - **Workshop Issues** *(recommendations, workshop report)*

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